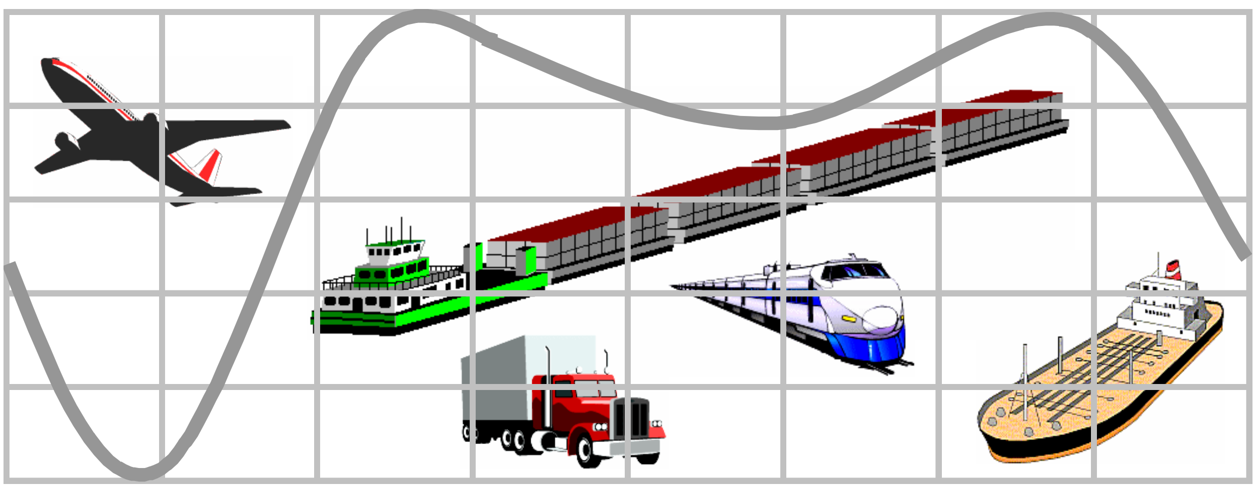
COMMERCIAL TRANSPORTATION OPERATOR FATIGUE MANAGEMENT REFERENCE

July 2003



U.S. Department of Transportation
Human Factors Coordinating Committee

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July 2003

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U.S. Department of Transportation
Research and Special Programs Administration

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Acronyms

AAR	Association of American Railroads
AMS	Acute Mountain Sickness
ASRS	Aviation Safety Reporting System
ATA	American Trucking Associations
CEM	Crew Endurance Management
CEWG	Crew Endurance Working Group
EST	Eastern Standard Time
FAA	Federal Aviation Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
OTC	Over-The-Counter products
REM	Rapid Eye Movement
TV	Television
USCG R&D	United States Coast Guard Research and Development Center
USCG	United States Coast Guard
VHS	Video Home System
WSF	Washington State Ferries

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Table of Contents

1. Introduction

Operator fatigue is a critical safety issue that affects all modes of commercial transportation. Fatigue can induce sleepiness and drowsiness, decrease the ability of workers to operate safely, and thereby increase the risk of fatalities and injuries.

The National Transportation Safety Board (NTSB) has found that the incidence of fatigue is underestimated in virtually every transportation mode, because it is so hard to quantify and measure. Many accident investigations do not obtain the information necessary to determine the contribution of fatigue; namely, the condition of the operators, the extent to which they have been deprived of sleep, and their state of alertness.

Analysis of accident and incident data suggest that fatigue may contribute to between 20 and 40 percent of commercial transportation accidents. Analysis of 182 heavy truck accidents that were fatal to the truck driver indicated that fatigue was a causal factor in 31 percent of these crashes.[1] The NASA Aviation Safety Reporting System (ASRS) is a confidential self-reporting system for flight crews and others to report difficulties and incidents. A study of ASRS incident reports suggests that 21% of incidents reported since its inception were fatigue-related.[2] A 1996 U.S. Coast Guard study reports the results of analyzing 297 commercial marine casualty investigations, using procedures specially developed to identify the contribution of fatigue to the accidents. Analysis of these reports indicated that fatigue was a contributing factor in 16% of vessel casualties and in 33% of the personnel injuries investigated.[3] Data providing a consistent and reliable indication of the role of operator fatigue in rail accidents are not readily available. However, researchers in this area generally agree that fatigue is a major contributor to rail accidents.[4]

Managing the fatigue of commercial transportation operators requires an understanding of the practical implications of fatigue research, as well as, the application of appropriate fatigue management practices. Fatigue research has been conducted to address a wide range of issues and operational settings. A number of operator fatigue management training workshops, guidelines, and handbooks have been developed to aid in the development of individual fatigue management programs. Fatigue management program elements and fatigue research findings can

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[1] National Transportation and Safety Board. (1990). *Fatigue, alcohol, other drugs, and medical factors in fatal-to-the driver heavy truck crashes* (Safety Study 1990, NTST/SS-90/01), Washington, DC.

[2] Graeber, R. C. (1985). *Proceedings of the Flight Safety Foundation 38th International Air Safety Seminar*.

[3] McCallum, M. C., Raby, M., & Rothblum, A. M. (1996). *Procedures for investigating and reporting human factors and fatigue contributions to marine casualties* (Final Report No. CG-D-97). Washington, DC: United States Coast Guard.

[4] Sussman, D., & Coplen, M. (March 2000). Fatigue and alertness in the United States railroad industry. Part I: The nature of the problem. *Fourth International Conference on Managing Fatigue in Transportation.* Freemantle, Australia.

be extracted from earlier efforts that have general applicability across a range of commercial transportation modes.

In recognition of the opportunity to provide a general fatigue management resource with broad applicability, the U.S. Department of Transportation's modal agencies are currently addressing fatigue management through a multi-modal, coordinated *Fatigue Management Program*. The development of this *Fatigue Management Reference* represents a portion of that programmatic effort. The purpose of this reference is to provide basic information to the transportation industry that can be used to enhance the content of fatigue management guidelines, handbooks, and educational materials. Objectives defined in support of this effort are:

- Compile information regarding those factors that can serve as indicators of potential fatigue problems within the commercial transportation industry,
- Describe the basic components shared by fatigue management programs within the commercial transportation industry, and
- Provide a series of summaries that address what is and what is not known regarding the efficacy, implementation, and limitations associated with fatigue countermeasures commonly employed in commercial transportation operations.

This *Fatigue Management Reference* has been developed with support from a group of 25 individuals who are central to operator fatigue management efforts for their organizations. Members of this group represent the airline, railroad, maritime, and trucking industries. The industry contributors shared the challenges they have faced and the lessons they have learned in managing operator fatigue within their organizations, shared the information resources they have used in managing fatigue, and served as critical reviewers of draft versions of this *Fatigue Management Reference.* A group of industry and government researchers also contributed to this reference by reviewing fatigue management research to date and compiling two sections that provide information on fatigue countermeasures and sleep basics.

This document contains nine sections,

Acronyms – provides a listing of all acronyms used in this reference.

Operational Fatigue Risk Factors – identifies those aspects of commercial transportation operations that may be associated with higher risk of operator fatigue.

Fatigue Management Program Components – outlines the basic components of ongoing, evolving, and successful alertness management programs in the commercial transportation industry.

Fatigue Countermeasures Review – summarizes what can be concluded from research regarding the use of those fatigue countermeasures that are most commonly considered for application in the commercial transportation industry.

Sleep Basics – provides information to support a basic understanding of the physiological and behavioral mechanisms that govern fatigue.

References – includes citations of all published research reports cited in the body of this document.

Additional Information Sources – lists reports and other documents that provide additional information on this topic.

Subject Index – provides a listing and page index to selected topics addressed in this document.

Glossary – provides definitions for various terms and concepts presented in this document

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2. Operational Fatigue Risk Factors

Introduction

Many factors associated with operator fatigue are common across transportation modes. This section discusses several general operational fatigue risk factors that were identified during structured interviews with representatives from the airline, railroad, maritime, and trucking industries.

When these factors are present, there is an increased likelihood that operators are working in a state of fatigue. Operational issues associated with these factors are discussed, and specific examples are identified within the airline, railroad, maritime, and trucking industries. By reviewing this section, commercial transportation operators can begin to identify the factors that may be of concern in their particular operations.

The operational fatigue risk factors discussed in this section are:

- Extended Work and/or Commuting Periods
- Split-Shift Work Schedules
- Sleep/Work Periods Conflicting with Circadian Rhythms
- Changing or Rotating Work Schedules
- Unpredictable Work Schedules
- Lack of Rest or Nap Periods During Work
- Sleep Disruption
- Inadequate Exercise Opportunities
- Poor Diet
- Environmental Stressors

Extended Work and Commuting Periods

Most commercial transportation operator work-hours are regulated by Federal hours-of-service rules. Therefore, long work hours seldom independently result in operator fatigue. Rather, it is the combination of long work periods and other non-duty factors that contribute to on-the-job fatigue, by limiting the available time for recreation, rest, and sleep. Over extended working periods, repeated inadequate sleep periods can result in accumulated sleep debt and associated operator fatigue. Among the primary aspects of extended work and/or commuting periods that have been cited as contributing to operator fatigue are:

- Long commutes to or from work on a daily basis
- Long waits after reporting for work before duty begins
- Forced interruptions in work that extend the duty day
- Long commutes from home to report for work prior to beginning a multi-day work period

Examples in Commercial Transportation

Airlines

- Crewmembers who have a minimum 8- or 9-hour rest period might not have schedule allowances for local commutes, meals, and personal care that can result in a sleep opportunity of less than 5 hours.
- Many airline crewmembers have long commutes to and from their home base. These commutes might not be taken into account by the individuals involved to ensure adequate rest prior to the upcoming work period.

Railroads

- Inadequate time for sleep can result from 12 hours on the job, coupled with the time required for local commutes, meals, personal care, and calls to or from the job dispatcher.
- Railroad employees can be on duty 18-20 hours or more, if stranded or in combination with deadhead moves.

Maritime

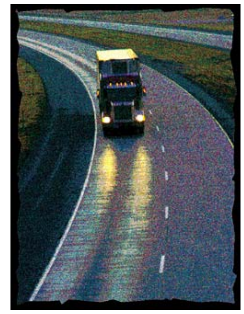
- Officers on deep draft vessels with collateral administrative or cargo duty might have limited time for sleep.
- Offshore supply vessel crews might report at company headquarters for the beginning of a work cycle, which is immediately followed by an extended commute to the vessel and reporting for work.

Trucking

- Drivers working regional or local routes sometimes perform dock work that breaks up their driving period, but adds to the duty period.

- Drivers often must wait for their truck to be loaded or unloaded before resuming driving, adding to the length of their duty day and reducing opportunities to obtain satisfactory sleep. Often during these periods, drivers do not have the opportunity to nap.

Split-Shift Work Schedules



Split-shift work can increase the likelihood of operator fatigue, by resulting in schedules that are not conducive to obtaining adequate sleep during the normal sleep period. Among the primary factors that commonly occur in conjunction with split-shift schedules contributing to operator fatigue are:

- Early morning start of shift
- Late evening end of shift
- High-paced operations during the work period
- Limited time at home during the awake period
- Difficulty in taking advantage of mid-day sleep opportunities

Examples in Commercial Transportation

Airlines

- Cargo, commuter, and other operations result in split shifts, with off-duty rest available for the crew either at an airport rest area or at off-site accommodations. Factors that can compromise obtaining rest, and thereby contribute to fatigue include: non-use of the rest facilities by crewmembers, facility conditions not conducive to rest, and the time of day.

Railroads

- Commuter operations can result in AM/PM split-shift operations with long periods away from home and insufficient time available for sleep.

Maritime

- Towing and offshore supply vessel crewmembers typically work a “square watch” of 6-hours-on/6-hours-off. There are pros and cons to these shifts versus 12-hours-on/12-hours-off schedules on offshore supply vessels and tugs working relatively high tempo operations: 6-hours-on/6-hours-off have shorter continuous work periods but result in multiple sleep periods, some with poor times; but 12-hours-on/12-hours-off have long work periods that may be too long if the physical or mental demands of the job are high, but provide for one continuous sleep period.
- Offshore supply vessel engineers will often have highly fragmented schedules, as they must be on duty when pumping product.
- The traditional deep-water watch schedule is 4-hours-on/8-hours-off with additional duties during daylight hours. The most challenging schedules are those that involve watches during normal sleep periods, and sleep during normal awake periods; that is, those that include the 0000-0400 hours and 0400-0800 hours watch periods.

Trucking

- The 24/7 nature of over-the-road (long-haul) driving often requires work during both the daytime and the nighttime, resulting in fragmented sleep and sleep opportunities at times not conducive to sound sleep.
- Team drivers may alternate driving and sleeping in the berth during travel, resulting in a split-shift work schedule.

Sleep/Work Periods Conflicting with Circadian Rhythms

When work schedules require people to obtain their sleep during times that are normally awake periods, the quality and quantity of sleep suffers. Work during "low" periods of the circadian rhythm (approximately 0100-0400 hours and 1300-1600 hours) can be associated with drowsiness and a low level of alertness.

Inappropriate times to obtain sleep include:

- Late morning (for those adjusted to a nighttime sleep schedule)
- Afternoon (for those adjusted to a nighttime sleep schedule)
- Early evening (for those adjusted to a nighttime sleep schedule)
- Any shift in sleep time due to travel across time zones that requires sleep during the day at the origin of travel (i.e., the jet lag phenomenon)

Examples in Commercial Transportation

Airlines

- International and transoceanic flights commonly have a domestic departure in the evening, resulting in all-night flights, followed by early morning return flights after a disrupted sleep period.
- Early wake-up times for early morning departures (e.g., 0300 hours wake-up for a 0600 hours departure) lead to fatigue problems that are difficult to compensate for by an earlier bedtime because the bedtime will be prior to a normal sleep period.
- Senior pilots will often select long-haul schedules that result in the most demanding work schedules because these typically result in the highest compensation and/or extended time at home.

Railroads

- Crewmembers frequently work various schedules over a period of days or weeks resulting in available sleep times that are at the wrong physiological time.
- The off-duty time of railroad crewmembers is frequently seen as the responsibility of the individual worker, even though work schedules might result in physiologically challenging sleep schedules.

Maritime

- A 6-on/6-off "square watch" starts at either 0000 or 0600 hours, with morning/evening sleep periods of 0000-0600 hours and 1200-1800 hours, which coincide reasonably well with normal circadian rhythms. However, the midnight/afternoon watch has sleep periods from 0600-1200 hours and 1800-0000 hours, which are at the wrong physiological times.

- Offshore supply vessel crew schedules are typically 12-on/12-off, beginning at 0600 and 1800 hours. This regimen results in a challenge for crewmembers scheduled to sleep between 0600-1800 hours because this sleep period is inconsistent with a normal nighttime sleep schedule. In addition, rest during this period can be further compromised by interruptions for docking and transfers.
- Deep draft vessel watch schedules are typically 4-hours-on/8-hours-off, with the most challenging schedules being those that involve watch schedules during normal sleep periods, and sleep during normal awake periods – those that include the 0000-0400 hours and 0400-0800 hours watch periods.

Trucking

- Long-haul driving often requires work during both the daytime and the nighttime, resulting in fragmented sleep and sleep opportunities at times not conducive to sound sleep.
- Local night routes and cross-country routes often involve nighttime driving and daytime sleeping.
- Team drivers might alternate driving and sleeping in the berth during travel, resulting in split-shift work schedules and scheduled sleep periods not conducive to sound sleep.
- Night drivers commonly shift to daytime schedules on weekends or days off, resulting in weekly disruption of their usual sleeping period.
- Depending on a drivers work schedule, Hours-of-Service rules can require the employer to schedule employees for off-duty periods that are not conducive to sleep (e.g., 1600-0200 hours), resulting in low-quality sleep immediately followed by a driving period beginning during a “low” circadian period (i.e., 0200 hours).

Changing or Rotating Work Schedules

Many commercial transportation operations require frequent changes or rotations in schedule. These schedule shifts lead to relatively quick changes in the time of day at which operators can obtain sleep, generally resulting in inadequate levels of rest. Changing or rotating work schedules can be characterized as follows:

- Changes in work and rest schedules that do not have a fixed pattern and thereby result in fatigue management challenges that are extremely difficult to address
- Rotating schedules that have fairly systematic shifts in the work start and stop times

Examples in Commercial Transportation

Airlines

- Crewmembers who work for supplemental operators (i.e., cargo carriers) often work at night; then, when off-duty, they might revert to a nighttime sleep schedule.

Railroads

- The generally unscheduled nature of freight operations in North America contributes to erratic duty start times.
- Many crews are rotated in "pools" on a first-in, first-out basis, often with no regularity in duty period. All possibilities of changing schedules (backward, forward, swing) are seen.

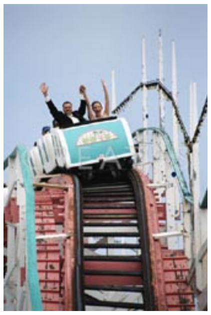
Maritime

- Crewmembers are required to be available on an as-needed basis to assist in mooring and transfer operations that are subject to changing schedules.
- Vessel captains are typically required on the bridge entering and leaving port, resulting in erratic work hours, especially on shorter routes.

Trucking

- Drivers who are "on call" for available work frequently do not have a fixed schedule.
- Drivers who must rely on a dispatcher to schedule pick-ups and deliveries are subject to changing schedules.
- Drivers who normally work at night may revert to a nighttime sleeping schedule when they return home.

Unpredictable Work Schedules



The amount of advance notice that commercial transportation operators have regarding their work schedule varies substantially. An unpredictable schedule can lead to forced changes in sleep times and therefore in low-quality sleep. Unpredictable schedules can also cause workers to wake sooner than necessary in order to check in with dispatchers. Conditions commonly associated with unpredictable work schedules include:

- Being “on-call” for work without a fixed schedule
- First-in, first-out work pool scheduling
- Schedule delays resulting from equipment, weather, or traffic problems

Examples in Commercial Transportation

Airlines

- Weather, traffic, and mechanical problems can result in unexpected delays.
- On-call crewmembers have limited advance notice regarding their schedules.

Railroads

- Employees who work “on call” (rotating frequently between day and night work schedules) account for between 40 and 60 percent of all crews.

Maritime

- Crewmembers typically have well-defined work periods. However, operational demands (docking, cargo transfer, or weather) can result in interruptions.

Trucking

- Driver work schedules at some trucking companies change on a weekly basis.
- Drivers who are “on call” for work have limited advance knowledge of their schedules.
- Drivers frequently experience delays in cargo delivery, loading, or unloading that force them to change their work schedule, varying on-duty versus driving time.

Lack of Rest or Nap Periods During Work

Taking a brief rest or nap during a work period is a controversial topic in some transportation settings while it is considered the norm in others. Research has demonstrated the value of planned napping to supplement sleep and to temporarily restore alertness on the job. Lack of rest or nap periods can result from:

- Company policies that restrict or prohibit napping
- Federal regulations that restrict or prohibit napping
- Unwillingness of operators to take naps

Examples in Commercial Transportation

Airlines

- FAA regulations forbid on-duty crewmembers from taking naps on domestic flights.
- Rest breaks of 2 to 3 hours are scheduled on long-haul international flights having 3 or 4 crewmembers – the first rest period is least desirable, middle most, last period next best.

Railroads

- Most railroads in North America now have policies that allow operating crews to nap under controlled conditions.

Maritime

- Crewmembers typically can only take advantage of napping opportunities during off-watch periods at port or during limited transit periods.

Trucking

- Companies vary in their napping policies for “long-haul” operations.
- Long-haul drivers typically nap on an as-needed basis. The naps taken are often extended and more accurately reflect split-shift schedules.
- Long-haul drivers typically know their routes and the locations of good rest stops and therefore can plan when and where to take naps, however,
- The lack of adequate rest stops limits the opportunity for resting or napping on many routes.

Sleep Disruption

Interrupting or disturbing sleep can make returning to sleep more difficult. It has been shown that both the number and timing of disruptions can affect daytime sleepiness and fatigue. Some general factors that disrupt sleep in commercial transportation operations include:

- ❑ Noise, vibration, movement, uncomfortable temperature, and poor air quality in sleeping quarters
- ❑ Unfamiliar environments away from home with less than optimal conditions
- ❑ Attempting to sleep at an inappropriate time for one's circadian rhythm
- ❑ Sleep at home or at hotels during normal awake periods can be disturbed by poor light shading, normal daytime noises, and sub-optimal heating and air conditioning

Examples in Commercial Transportation

Airlines

- Crewmember rest can be disrupted by unpredictable aircraft movement, turbulence, vibration, and/or noise.

Railroads

- Crewmember rest can be disrupted by dispatchers, who are allowed to call crewmembers regarding upcoming work up to 90 minutes before report time.

Maritime

- Live-aboard crewmembers must often deal with sleep disruption due to vibration, noise, and motion.
- Work-related interruptions during scheduled sleep periods are a common problem on many vessels.
- Sleep disruption tends to be common aboard at-port vessels because docks are busy and vessels must move frequently.
- Senior deck officers must balance bridge availability during operations with significant risk (docking, etc.) and the cost in disrupted sleep and cumulative fatigue.

Trucking

- Drivers with sleeper berth cabs face the challenges of either noisy rest stops or trying to sleep in the vehicle while traveling.

Inadequate Exercise Opportunities

People who exercise regularly have fewer episodes of sleeplessness. Isolated exercise, while not an effective countermeasure for immediate fatigue, can improve sleep quality by promoting smoother, more-regular transitions between the cycles and phases of sleep. Moderate exercise lasting 20 to 30 minutes, three or four times a week, promotes sleep. Exercise in the morning or afternoon is preferred, because exercise close to bedtime can disrupt the onset of sleep. A brisk walk can be very beneficial, although more vigorous exercise has been shown to provide increased health benefits. Exercises designed for environments with restricted space have also been shown to be beneficial. Factors that may limit exercise opportunities include:

- ❑ Personal habits might need to be overcome in initiating an exercise program
- ❑ Work schedules might need to be adjusted to include appropriate exercise opportunities
- ❑ Travel or living conditions can limit access to exercise equipment or space

Examples in Commercial Transportation

Airlines

- Crewmembers whose workdays are extended can have difficulty obtaining adequate exercise well in advance of their sleep period.

Railroads

- Crewmembers whose workdays are extended can have difficulty obtaining adequate exercise well in advance of their sleep period.

Maritime

- Crewmembers who work onboard frequently have limited exercise options. Some deep-draft vessels provide exercise equipment and/or have an adequate area for walking.
- Some maritime companies regard exercise equipment as dangerous under their operating conditions. In general, maritime workers must establish a regimen of exercise in a confined space with limited equipment.

Trucking

- A number of companies have been encouraging their drivers to take a brisk walk mid-day, prior to lunch.
- Truckers generally have difficulty making suitable time available for exercise, locating appropriate places to exercise, and ensuring privacy and personal security while exercising.

Poor Diet

What we eat can be a determining factor in sleep quality and duration. Some of the dietary behaviors that can disrupt sleep include:

- ❑ Eating heavy or spicy foods just prior to bedtime, which can interfere with sleep by causing heartburn
- ❑ Consuming alcohol just prior to bedtime can induce sleep initially, but tends to lead to fragmented sleep
- ❑ Consuming caffeine within 4 to 6 hours before bedtime can delay the onset of sleep as well as disrupt sleep

Examples in Commercial Transportation

Airlines

- Meals provided in flight might not be appropriate for a crewmember's work schedule.

Railroads

- Hotel menus with limited healthy entrees cannot always be avoided, because many on-route hotels are located in sparsely populated areas with few available alternatives.
- Meals available to crews might not be appropriate for a crewmember's work schedule.

Maritime

- Menus traditionally include large servings of carbohydrates and fried foods.
- On smaller vessels, prepared meals might be limited to one per day.
- On board, the availability of fresh fruits and vegetables might be limited.

Trucking

- Drivers are not traditionally the healthiest of eaters, and truck stops are not traditionally the healthiest of purveyors.
- Although drivers can take food with them, poor dietary habits and/or a lack of dietary education often lead them to choose foods that are less than healthy.

Environmental Stressors

Several environmental factors can adversely affect a commercial transportation operator's level of alertness. These include environmental aspects related to heat, humidity, cold, altitude, vibration, and noise.

Heat and Humidity

Generally, one experiences high ambient temperatures as dry heat (temperature above 85° F, humidity less than 50%), or as humid (temperature above 85° F, humidity above 80%). All excessively hot conditions will make an operator feel less alert and generally more fatigued. Hot and humid working conditions can be significantly more detrimental to worker performance than can hot-dry conditions, and will usually make one feel "fatigued" much sooner than will temperatures less than 75° F. The increased feeling of fatigue attributable to hot-humid conditions manifests itself in the form of excessive perspiration, dehydration, a sense of tiredness, and a generalized feeling of physical and mental fatigue. Using air-conditioning, taking frequent rest breaks, and drinking lots of fluids (preferably water) can help ward off the fatiguing effects of high ambient temperatures.

Cold

Cold weather can indirectly contribute to operator fatigue. Operators often wear several layers of clothing during cold weather, which can make using restroom facilities more difficult, which in turn can lead operators to reduce the amount of liquids they consume. Reduced liquid consumption can then lead to dehydration, which can cause operators to become fatigued more quickly than usual. Following a good regimen of fluid intake is recommended.

Aviation Altitude

At high altitudes, commercial crews often travel for extended periods in cabins pressurized at the 6,000- to 7,000-foot level. Breathing air at this level, with its reduced oxygen concentration, can lead to a general sense of fatigue, especially when the body is subjected to periodic rises and falls in pressurization.

High Terrestrial Altitude

Driving at altitudes in excess of 5,000 feet can increase a driver's respiration and heart rate; and sleeping at high altitudes can result in blood pooling in the arms and legs, which can cause the general malaise and discomfort that accompanies Acute Mountain Sickness (AMS). These effects dissipate as one acclimates to a higher altitude, usually in a matter of a few days. Drivers should be aware of the effects of high altitude, and, if at all possible, should avoid sleeping at high altitudes.

Whole Body Vibration

Whole body vibration and acceleration accompany operation of several types of transportation vehicles, including aircraft, helicopters, large trucks, trains, ships, and small vessels. Operation of helicopters, automobiles, trucks, etc., exposes operators to increasing acceleration magnitudes, with a frequency range extending up to

100 Hz, depending on the roughness of the air/road/seas and the vehicle speed. Ship-at-sea motions can extend from the extremely low frequencies produced by ocean waves (below 0.1 Hz) to the high frequencies produced by high-speed surface ships. Occasional air turbulence can superimpose vibration and buffeting on sustained accelerations in commercial aircraft. Although most operators consider these to be lower-level fatiguing effects, they can add to operators' general feeling of fatigue, thereby lowering their alertness while operating equipment, especially if they are exposed to these effects over long duty days.

With the help of air traffic controllers, commercial pilots in "rough air" seek out less vibratory altitudes for the comfort of their airline passengers. Truck drivers often avoid roads known to be rough, especially if they are team-drivers with one driver attempting to sleep in a sleeper-berth while the other drives. As potential countermeasures, operators can install high-quality shock-absorbing systems, sit on air-cushioned seats, or avoid vibration environments.

Acoustical Noise

Operators are exposed to engine noises in all transportation vehicles, as well as to related noises emanating from aircraft controls, vehicle transmissions, braking systems, and wind streams. Some people regard these noises more as a hearing-conservation issue than as a fatigue issue. In fact, wearing ear protection in the presence of these noises is often called for; however, these noises can also contribute to an operator's level of fatigue. The continuous "hum" and other intermittent noises of most running engines, especially in hot and stuffy crew compartments, can contribute to the hours of boredom one can experience on lengthy trips. Being aware that noise can contribute to one's overall feeling of operator fatigue is an important step toward ensuring that operators take occasional rest breaks.

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3. Fatigue Management Program Components

Introduction

Commercial transportation operator fatigue is best managed by an integrated program that addresses the requirements of all stakeholders in the operational community. Evolving fatigue management programs often begin by attempting to implement countermeasures in the absence of such a program. However, this approach typically meets with limited success, because the individual implementations are not sufficiently understood or supported by all those affected by them. More mature and established fatigue management programs, on the other hand, introduce fatigue countermeasures from a foundation of organizational commitment, cooperation, knowledge, assessment, and program refinement.

A number of comprehensive program guides, developed for specific transportation modes, provide useful models of fatigue management program practices for the modes addressed.[5] In addition, specific programs tailored to the requirements of individual organizations have been developed by a number of commercial transportation organizations.[6] These guides share a number of themes and lessons in common, suggesting a central core of key fatigue management program components. Taken as a starting point, these key components can be tailored to the operational requirements of individual transportation organizations.

This section discusses the general nature of the key components of fatigue management programs, and provides examples that have been obtained from industry participants on this project. The following five program components are discussed in the remainder of this section:

- Organizational Commitment
- Employee-Employer Partnership
- Education and Training
- Employee Health Screening
- Program Evaluation and Refinement

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[5] Selected examples of modal guides include: *The Alert Driver – A Trucker's Guide to Sleep, Fatigue, and Rest in our 24-Hour Society*, American Trucking Associations, Inc., and the Federal Motor Carrier Safety Administration, 1997; *Crew Factors in Flight Operations X – Alertness Management in Flight Operations*, NASA Ames Research Center, 1999; *Management of Endurance Risk Factors – A Guide for Deep Draft Vessels*, United States Coast Guard Research and Development Center, 2001; *Shiftwork Coping* Strategies, FAA Civil Aerospace Medical Institute, 2001; and *Toolbox for Transit Operator Fatigue*, Transportation Research Board, 2002.

[6] Selected examples of fatigue management program guides developed by individual commercial organizations are: *The Alert Employee – A Guide to Sleep, Fatigue, and Rest in our 24-hour Society*, Federal Express, 1997; *Alertness Management Guide*, Delta Air Lines, 2001; and *Crew Endurance Management Practices for Washington State Ferries*, 2003.

Organizational Commitment

In order to succeed, a fatigue management program needs visibility and support at the highest levels in the organization. Organizational commitment requires the allocation of resources sufficient for establishing and sustaining a fatigue management program. Involvement by the upper levels of the organization in supporting, monitoring, and refining the program is required for continued program success.

Senior executives should be involved in the formulation and support of their organization's fatigue management policy. Program policies should be established through a joint effort by all organizational stakeholders. The policy *might* include:

- Statement of goals and objectives
- Responsibilities and authority for managing fatigue and alertness
- Documentation of the support and expertise available to the program
- Policies regarding employee alertness and fatigue
- Objectives and methods for program evaluation and refinement

Each of the four commercial transportation modes that have actively participated in the present project operates under hours-of-service rules. Thus, every organization must, to some extent, address operator fatigue in their operations. However, there is ample evidence that meeting the nominal requirements of current hours-of-service rules is not sufficient to effectively manage operator fatigue – additional efforts are required. There are numerous examples of organizational commitments to manage operator fatigue beyond hours-of-service rules within commercial transportation. However, rather than identifying any specific company's activities in this regard, it may be more useful to characterize the general nature of commitment within the airline, railroad, maritime, and trucking industries.

The **airline** industry has long been considered a safety critical industry, with a substantial level of effort devoted to engineering and operational safety. Following the introduction of the NASA Ames Fatigue Management Training Module, organizational involvement among airlines generally grew. At present, most U.S. airline carriers have established some variant of a fatigue management program.

The **railroad** industry has been a leader in fatigue management, sponsoring a substantial level of research, and committing to long-term programs, in spite of many economic disincentives for reducing worker hours. Sherry[7] describes numerous early efforts to establish and test modified work/rest schedules in an effort to reduce on-the-job fatigue.

The **maritime** industry was introduced to fatigue management somewhat later than the airline and railroad industries. Following the release of a study documenting the

[7] Sherry, P. (2000). *Fatigue Countermeasures in the Railroad Industry: Past and Current Developments*. Washington, DC: Association of American Railroads.

substantial role of fatigue in maritime casualties by the Coast Guard in 1996,[8] there has been a growing involvement in fatigue management within this industry. The Coast Guard leads this effort, providing assistance and guidance through its *Crew Endurance* program to maritime companies willing to invest in fatigue management.

The **trucking** industry is extremely diverse, in both the size of organizations and the nature of operations. Not surprisingly, this diversity has resulted in a wide range of levels of commitment by operating companies. Some trucking carriers have well-established, integrated programs, while others simply manage hours-of-service. However, it is noteworthy that industry organizations (e.g., American Trucking Associations) with the support of the federal government have developed educational programs that are proving quite effective in introducing the issues associated with truck driver fatigue and fatigue management.

[8] McCallum, M. C., Raby, M., & Rothblum, A. M. (1996). *Procedures for investigating and reporting human factors and fatigue contributions to marine casualties* (Final Report No. CG-D-97). Washington, DC: United States Coast Guard.

Employee – Employer Partnership

It is a challenge for employees and employers to address fatigue management from a common perspective. At issue are work and rest schedules, which directly affect both operational efficiency and operator well being. On the other hand, because these issues are so critical to the organization and individuals (reducing on-the-job accidents, improving employee health, and improving operational efficiency), they can also serve as an important basis upon which to establish more productive relationships. An effective alertness management program must identify a means of involving both employees and employers in supporting these common objectives. Employees and employers are most effective when they work together to address employee fatigue.

The **Association of American Railroads** (AAR) provides a relatively early example of employee-employer cooperation in fatigue management. In 1992, AAR began research of the work/rest and fatigue issues through the formation of the *Work Rest Task Force* with participants from a number of major railroads and unions. The planned research had two major objectives: (1) to create a validated system for describing and measuring factors associated with work schedules in the railroad industry; and (2) to determine, if possible, how accidents and injuries are related to measurable work factors. Over a period of four years, using data from five major railroads, researchers met the first objective by developing methods for describing and translating shift work data. The second objective has not yet been satisfactorily achieved. *The Work Rest Task Force* is continuing its efforts to address the fatigue concerns in the industry. The Task Force collaborated with the *North American Rail Alertness Partnership*, consisting of members from the Federal Railroad Administration (FRA), rail labor unions, and the carriers, to identify the key principles of an effective fatigue countermeasures program. A committee of senior railroad executives officially endorsed the list on February 23, 1998 and railroads are continuing to integrate the countermeasures principles into their individual programs.

The **Washington State Ferry System** (WSF) provides a more recent partnership example in the maritime industry. In 2001, at the urging of the United States Coast Guard, the WSF formed a *Crew Endurance Working Group*. The group consisted of WSF management, the U.S. Coast Guard (USCG) Research and Development Center team, and employee representatives. The purpose of the group was to study crew endurance and fatigue factors at WSF and to improve conditions that were found. WSF dedicated the funds necessary for the meetings and the ongoing education and training. The USCG R&D team acted as facilitators at the meetings and provided research and data for the group to consider. They have studied various crew work schedules and provided information needed for training and education for fleet personnel. The USCG Marine Safety Office representatives were there on behalf of the USCG which has regulatory responsibility over working conditions on WSF vessels. Employee representatives supporting fleet personnel have become “Crew Endurance Coaches,” and are involved in ongoing training and education. At the time of this writing, the group still meets on a regular basis and both employers and employees are now fully committed to the *Crew Endurance Working Group* and the ongoing program.

Education and Training

Education and training provide the knowledge required to support the fatigue management program at all levels. Education should address the physiological mechanisms that underlie fatigue, provide specific recommendations for countermeasures, and be industry specific. Information should be distributed industry-wide through a range of forums and formats. Information should be provided frequently, in order to foster behavioral change. Periodic revision of training materials is required to incorporate new information and techniques.

Union Pacific Railroad has a long-standing education and training program for employees. This program, called the *Alertness Management Program* has been developed and delivered at three levels:

1. A short video program is used at company meetings and in a safety blitz format.
2. A video program is used in conjunction with a trained facilitator.
3. A live presentation is given by a trained facilitator.

Washington State Ferries, in its recent efforts to address operator fatigue, has confronted the basic requirement of educating the workforce prior to introducing major changes in work schedules. One of the first actions of Washington State Ferries' *Crew Endurance Working Group* (*CEWG*) was to drastically alter some longstanding work schedules. Although it had been shown that these work schedules had negative health and safety implications, changing them was very unpopular with fleet personnel who had become accustomed to them over a long period of time. The *CEWG* quickly recognized the need for training and education and had *CEWG* members visit every crew and provide information regarding proper diet, exercise, and sleep. The WSF *Fire and Safety Training* book was updated with information regarding Crew Endurance. All new employees and new Deck Officers were trained in endurance and fatigue management during their orientation. Even after this educational effort, there continues to be resistance from rank and file personnel. Change does not come easily to people who feel that their lives have been disrupted; so the training is being expanded and presented to all vessel crews during a one-day seminar on various safety issues, with a segment devoted to endurance and fatigue. The training is being conducted by employee representatives of the *CEWG* using information provided by the USCG R&D Center team. There has been some very gradual shifting of attitudes from fleet personnel regarding work scheduling and fatigue management, and people are starting to understand the importance of proper sleep, exercise, and diet.

Since 1996, the Federal Motor Carrier Safety Administration and the **American Trucking Associations** have co-sponsored and conducted "train-the-trainer" fatigue management courses for over 3700 safety and risk managers in the trucking industry. The goal is to provide training material to safety officers, which they can use to foster alertness and fatigue management programs in their own companies. The program offers a 19-minute family-oriented VHS video on driver fatigue, accompanying helpful booklets and pamphlets, a set of over 50 PowerPoint slides, and a comprehensive lecture to accompany the course. The FMCSA-ATA course, *Mastering Alertness and Managing Commercial Driver Fatigue*, covers such topics as: the importance of obtaining adequate rest and sleep, body and sleep physiology, circadian rhythm effects, shift-lag influences from rotating work schedules , sleep disorders, the influences of chemical substances, a list of drowsy driver warning signals, and a set of fatigue countermeasures.

Employee Health Screening

Sleep disorders disrupt sleep, and can lead directly to operator fatigue, or exacerbate fatigue associated with a challenging work schedule. There are a number of self-screening tools for fatigue that can be used by operators to determine their need for further help.[9]

Several **railroad carriers** have *confidential* screening programs in place that provide employees information about sleep disorder symptoms and information about where to go for help. Carriers have experimented with formal medical screening but find that employees are more comfortable with and more likely to use confidential voluntary programs.

American Trucking Associations' *The Alert Driver* guide includes a comprehensive chapter entitled *Do You Have a Sleep Disorder?* The chapter includes sections addressing sleep apnea, insomnia, leg twitches, narcolepsy, advanced and delayed sleep phase syndrome, and advice on seeing a doctor if a serious sleep disorder is suspected.

[9] The National Sleep Foundation provides a useful *Excessive Daytime Sleepiness Questionnaire* that can be accessed and scored online at the following world wide web site: http://www.sleepfoundation.org/epworth/quiz.html. Accessed July 9, 2003.

Program Evaluation & Refinement

A fatigue management program requires periodic evaluation and refinement, as with any other aspect of an effective business operation. Program evaluation should be linked to the established objectives. Measures that could be collected on an ongoing or periodic basis include: hours of charged operator overtime, average number of operator sick days, number of accidents and incidents found to have resulted from operator fatigue, attendance at alertness management educational events, number of operators completing confidential fatigue-screening, and operator responses to a periodic alertness management survey.

Program refinements close the gap between established objectives and evaluation findings. The process of effectively managing operator alertness inevitably involves coordinating efforts across many members and levels of an organization. Successful refinement requires continued oversight and revisions to improve the alertness management program.

British Airways provides a recent example of program evaluation, conducted to assess the education section of their *Alertness Management* program approximately two years after the introduction of the *Alertness Management Manual* and trip specific advice cards. Evaluation involved a non-compulsory survey of flight crewmembers. Analysis of the survey indicated that satisfaction with the program was generally high with regard to presentation, readability, and ease of use of the manual. Additionally, analyses identified two groups of pilots who found the information most valuable: (1) pilots new to long-haul operations; and (2) those working in a rapidly growing and evolving long-haul fleet where even experienced crew were frequently presented with new schedules or destinations for which trip specific guidance on rest and alertness was particularly valued.

The Association of American Railroads and the **Burlington Northern Santa Fe** evaluated an effort to develop a 10-days-on and 5-days-off scheduling agreement for locomotive crews (Sherry, 2000).[10] Several methods were used in the evaluation, including self-report, objective measures, and performance-based measures of fatigue. The study involved the pre and post assessment of the engineers who were assigned the 10/5 schedule. A baseline observation period was conducted during October 1998, and post testing was conducted in December 1999. The results indicated that this approach produced a positive change in the lives of the participants in the 10/5 scheduling program. For the most part, participant's comments regarding the effects of the scheduling program were positive. In general, the subjective impressions of this program indicate that it met with moderate approval by the participants and reduced fatigue on several subjective measures.

[10] Sherry, P. (2000). *Fatigue Countermeasures in the Railroad Industry: Past and Current Developments*. Washington, DC: Association of American Railroads.

4. Fatigue Countermeasure Review

Introduction

Strategies for reducing fatigue are referred to as “fatigue countermeasures.” This section discusses 20 fatigue countermeasures. Research indicates that some of these countermeasures are effective, some are probably effective (but are still being studied), others require medical supervision, and some simply do not work or have harmful health effects.

Countermeasures That Work

The countermeasures described in this category are effective as shown by research data and operational experience. They encompass both the *prevention* of fatigue by getting enough sleep and the *mitigation* of fatigue through countermeasures applied when you are getting tired. Individual countermeasures will need to be combined, based on your specific operational circumstances. The countermeasures included in this category are:

- Adequate Sleep
- Caffeine
- Napping
- Anchor Sleep
- Trip Planning
- Good Sleeping Environment

Countermeasures That Are in the Research Phase

The countermeasures described in this category show promise for reducing fatigue, but they are some distance from practical application, and are not available for implementation without the assistance of fatigue research professionals. This is because of the relative complexity of the procedures, difficulties of practical everyday implementation, and in some cases, insufficient demonstration that they would be effective in a real-life environment. The countermeasures included in this category are:

- Models of Alertness
- Fitness for Duty Testing
- Alertness Maintenance Monitoring

Countermeasures That Require Supervision by a Physician

The countermeasures described in this section either require a prescription by a physician (e.g., drugs such as stimulants or hypnotics), or require guidance by a person trained in circadian physiology for best application (e.g., melatonin). Countermeasures in this category should be used with care, since side effects and dependencies can develop. Also, there are regulatory prohibitions on drug use for transportation operators, as well as legal requirements for prescriptions.

These countermeasures include:

- Bright Light
- Stimulants
- Sedatives/Hypnotics
- Melatonin

Countermeasures That Are Ineffective, Have Minimal Effects, or Cause Health Problems

This section discusses a number of approaches that have been advocated as fatigue countermeasures, but lack scientific data demonstrating their effectiveness (e.g., diet or aromatherapy), or may cause health problems such as the use of tobacco and/or nicotine. These approaches are not recommended under any circumstances. Other countermeasures that have been commonly reported, such as exercise, diet, listening to the radio, or rolling down the window have minimal or no impact on fatigue, even though people think they do – these can be especially dangerous since drowsy people might believe they are OK when in fact they are impaired. The countermeasures included in this category are:

- Nicotine
- Ventilation and Temperature
- Exercise
- Diet
- Sound
- Odor/Fragrance
- Over-the-Counter Sleep Aids

The following pages have detailed descriptions of each countermeasure, including a definition, limitations of use, advantages to its use, and considerations in its application. Each description is also accompanied by selected references that are provided to give the reader more information about its scientific and operational aspects.

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Countermeasures That Work

Adequate Sleep

Definition and Scope

Preventing fatigue by ensuring adequate sleep opportunities, proper sleep-period timing, and appropriate accommodations.

Limitations of Use

The limitations associated with this countermeasure tend to involve factors that often are beyond the control of the individual, such as work shift start times, rotation of schedule, and location factors that might influence sleep, such as jet lag or the sleep environment. Additionally, some individuals tend to sacrifice adequate sleep for purposes of social or family activity; however, these factors involve individual choice and can be balanced as required.

Advantages to Use

The most effective countermeasure for fatigue is to do as much as possible to prevent it from occurring in the first place. As the material in the last section of this handbook suggests, the primary culprit for feeling fatigued is *sleep loss*. So, whatever can be done to obtain regular sleep and to prevent sleep loss should be high on the list of countermeasures. The principal advantage of getting enough sleep is that it will reduce on-the-job fatigue, thereby reducing the need for other countermeasures.

Things to Consider

The first general strategy for minimizing sleep loss is to establish a **routine approach to obtaining sleep**, that allows enough time to **obtain sufficient sleep**, and ensures an appropriate **sleep environment.** This means going to bed at the same time every night and waking up at the same time every day, allowing for at least eight hours of rest. This regularity establishes a pattern linked to the circadian rhythm and makes it easier to go to sleep and wake up. The sleep environment should be quiet, dark, and not overly warm. Unless the operator is sleep deprived, long naps should be avoided during the day, as they will interfere with falling asleep during the main sleep period.

Transportation workers often change shift schedules from one week to the next, or more frequently. This can lead to sleep loss because the body is not adapted to sleeping at a different time of day. The best approach for reducing sleep loss associated with a new shift schedule is to start the new shift with no sleep debt – this means getting at least two nights of unrestricted sleep prior to beginning a new schedule. If making a *radical* schedule shift, such as between days and nights, it will also be important to obtain some *compensatory* sleep prior to the new shift start. For example, if the schedule starts at midnight Sunday, it would be desirable to get two full nights of sleep on Friday and Saturday, sleep as long as possible on Sunday morning, and try to nap for a couple hours before the start of the midnight shift on Sunday. Napping prior to extended periods of wakefulness will reduce fatigue and improve alertness.

A third general approach to minimizing sleep loss is to match work schedules to individual physiology. Morning people (i.e., a "lark"), perform best on work schedules with early morning starts (e.g., 0700 hours or before). Night people (i.e., an "owl"), perform best on work schedules that start in the afternoon or night hours. In either case, it is important that individual physiology be coupled with a sufficient main sleep period.

Countermeasures to Minimize Sleep Loss:

- Have a regular routine for sleep
- Obtain sufficient sleep
- Ensure your sleep environment is appropriate
- Start new shift schedules with minimal sleep debt
- Obtain *compensatory* sleep before new schedule
- Match your regular work schedule to your personal physiology: "lark" or "owl"

References

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Countermeasures That Work

Caffeine

Definition and Scope

Increasing alertness by consuming caffeine in the form of coffee, tea, soft drinks, or chocolate; or by taking non-prescription caffeine tablets.

Limitations of Use

Our bodies gradually build up a tolerance to repeated consumption of high levels of caffeine (e.g., 5+ cups of coffee per day). A frequent coffee drinker may need a higher dose of caffeine to obtain the same "boost" effect of the more casual coffee drinker. Caffeine should be consumed caffeine sparingly, to "save the boost effect" for when it's really needed. That is, plan to use caffeine in the middle of the afternoon dip (1330-1530 hours) or if working through the night, use it after midnight during the circadian low point (0100-0430 hours).

Advantages to Use

One of the most commonly used fatigue countermeasures is caffeine, usually obtained through a cup of coffee. Other popular drinks and foods contain a lot of caffeine, including cola drinks, chocolate, and tea. Numerous medications also contain caffeine, as do "alertness aids" such as No-Doz and Vivarin. Caffeine is widely available and can have the advantage of breaking up a tiring work routine, e.g., a long, monotonous drive.

Caffeine Content from Various Sources

Percolated Coffee	**140 mg / 7 oz**
Brewed Coffee	**80-135 mg / 7 oz**
Red Bull Energy Drink	**115 mg / 12 oz**
Jolt Cola	**72 mg / 12 oz**
Coca-Cola	**34 mg / 12 oz**
Tea	**70 mg / 6 oz**
Chocolate	**5-35 mg / 1 oz**
No-Doz or Vivarin	**200 mg / tablet**
Excedrine	**65 mg / tablet**
Dristan	**30 mg / tablet**

Caffeine affects your nervous system within 15 to 20 minutes. The effects include a more rapid heartbeat and increased alertness, and they last for about 4 to 5 hours, but may last up to 10 hours in especially sensitive individuals.

Things to Consider

It is important to use caffeine only as a short-term way to boost alertness; regular use can lead to tolerance and various undesirable side effects, including elevated blood pressure, stomach problems, and insomnia and disrupted sleep if taken too close to bedtime.

Here are some situations where using caffeine makes sense:

- In the middle of a night shift (especially on the first and second day of the work week when circadian disruption is most pronounced and alertness most compromised)
- Mid-afternoon when the post-lunch alertness dip is greater because you didn't get enough sleep
- Prior to an early morning commute following a night shift, but not within 4 hours of going to sleep because it will keep you awake

It is always best to try and reduce fatigue through obtaining enough sleep, but when this doesn't happen and you need to boost alertness for a period of several hours, using caffeine makes sense.

Caffeine will affect sleep and should not be consumed 4 to 5 hours prior to sleep. Caffeine in the body will make falling asleep more difficult, reduce sleep length, and disrupt the quality of sleep.

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Countermeasures That Work

Napping

Definition and Scope

Using napping as a fatigue countermeasure involves sleeping for brief periods during work or other awake periods.

Limitations of Use

Napping should not be used as a substitute for getting enough sleep during your regular sleep period. Additionally, naps should be limited to a time and duration that will not interfere with regular sleep periods. Napping too close to bedtime will produce a boost in alertness that may make it difficult to fall asleep during the regular sleep period.

Advantages to Use

Taking a nap can help to reduce fatigue and increase alertness on the job, or at other times. Naps can be effective as a short-term countermeasure to fatigue, or to compensate for periods when you will need to remain awake for a long time, such as when you change shifts.

Napping is OK when you need to remain alert but have not obtained enough sleep because of uncontrollable circumstances. It is important for you to recognize that because of reduced sleep, you are at risk of being critically fatigued. Some general situations where napping would be appropriate are:

- You slept for less than 6 hours during your main sleep period
- You were awake for 30 minutes or longer two or more times
- You felt as if you were continually drifting in and out of sleep
- You felt much more tired than usual upon awakening from your regular sleep period

Things to Consider

When using napping as a countermeasure, it is important to think about the following:

- Where to take the nap?
- When to take the nap?
- How long to nap?

These questions will have different answers depending on the nature of your work. If you are a merchant mariner, your sleeping quarters are very likely close to your work area, making the issue of where to nap easy. Truckers may have sleeper berths, but need an off-road location to use them. Timing and duration are other critical elements of the nap countermeasure that need consideration in advance – if you wait until you are critically fatigued you are already in the danger zone.

Taking a nap should be timed to obtain the maximum benefit. This will vary depending on your circumstances, but in general the following guidelines are applicable:

- Take 10-12 minute “power naps” almost anytime as needed, as they can help refresh you for a short period of time.
- Napping for longer periods (2+ hours) prior to the start of a night shift can restore energy levels and is very beneficial.
- If you are day-oriented and not sleep deprived, avoid napping during the hours of 1000 to 1200 when alertness is usually high.
- Schedule a nap during the mid-afternoon (1300 to 1500 hours) when alertness is low (see section 5-2 for additional detail).
- Naps during work periods should be limited to 45 minutes to minimize waking from deep sleep (stages 3 and 4) where it can take more than 30 minutes to become fully alert.
- Allow 15-30 minutes after a nap to become fully alert. The deeper the sleep the longer the period needed to become fully alert.
- Napping is part of a continuous, non-split shift duty period, and should not be used to extend the duty period.
- Use an alarm clock to assist in waking up

There may be times when you feel overwhelmed by sleepiness despite “strategic naps” or a sufficient sleep period before work. In this case, you should take an “emergency nap” of 15 to 30 minutes as soon as your work activity permits. If you are on duty, you will need to use other countermeasures until you get to a good time or place for a break.

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Countermeasures That Work

Anchor Sleep

Definition and Scope

Anchor sleep refers to a regular sleep period of at least four hours duration, obtained at the same time each day. The anchor sleep period is supplemented by an additional sleep period taken when the schedule allows.

Limitations of Use

Anchor sleep should be used as a coping mechanism for situations where you cannot get a full eight hours of sleep, but not as a routine. While split sleep periods may give you a sufficient amount on a short-term basis, getting your full sleep allotment in a single episode is preferred.

Advantages to Use

Some work schedules do not allow you to get a full eight hours of sleep at the same time period every day. Examples include long-haul truck driving and maritime operations. In order to effectively cope with schedules like these, you should arrange to get at least four hours of sleep at the same time every day; additional sleep can be obtained as your schedule permits.

Anchor sleep periods have the advantage of stabilizing your circadian rhythm to a 24-hour period, so that you do not constantly feel "out of synch." You can time the anchor sleep period so that your circadian rhythm high and low points correspond to your work and sleep periods.

Things to Consider

Anchor sleep is not a substitute for getting a full eight hours during any 24-hour period. Instead, it is a coping mechanism meant to keep your circadian rhythm synchronized to your daily schedule, by allowing you to sleep for a period of time when you *can* sleep. It is important to supplement anchor sleep with supplemental naps that are sufficient to give you the complete sleep allotment that you need on a daily basis. This countermeasure anchors the sleep cycle.

Research data indicate that it is important to have the anchor sleep period occur at a constant time every day, so if you are going to use this approach, make sure your schedule allows this. You will also need to consider when you will take your supplemental sleep periods, since it may be tempting to simply "push through" any low point in the day thinking that you have got just enough sleep to keep you going. This will not work and can endanger yourself and others.

Meals should be taken at the times you normally eat. When you take your supplemental sleep, make sure that you don't get it so close to your anchor sleep period that you interfere with it. You should also be careful about caffeine consumption when using this routine, because you may be tempted to drink coffee or other caffeinated beverages near the times you will be going to sleep.

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Countermeasures That Work

Trip Planning

Definition and Scope

Use knowledge of the length and structure of your trip to plan rest intervals prior to and during the trip.

Limitations of Use

The limitations on trip planning involve factors that are often outside of your immediate control, such as when your work shift starts, the availability of rest areas, and the pace of your operations. In general, though, trip planning is an effective approach to starting work more refreshed, and alleviating fatigue while on the job.

Advantages to Use

The primary advantage of trip planning is that you can *anticipate* those times at which you will be feeling fatigued, and do something about it before it lowers your performance to unsafe levels. It also provides you with some structure along your route so that you won't be tempted to overextend yourself. Proper use of trip planning and the associated rest intervals will keep you from getting so fatigued that you may have an accident, and also allows you to plan where and when to sleep for your main sleep period during multiple day trips.

Things to Consider

Trip planning can be considered both a *preventive* countermeasure, as well as an *operational* approach. Trip planning would involve ensuring that you are properly rested prior to starting a trip – this would entail getting enough sleep during your main sleep period, and taking a nap prior to a trip start time that occurs during your normal sleep period. Many mariners, for example, take a fairly long nap prior to docking in the middle of the night. Similarly, airplane pilots might nap prior to a red-eye flight.

The *operational* approach to trip planning involves determining where and when you might be able to rest during transit. This will vary substantially by transportation mode, but in general should involve a safe, quiet, and comfortable place where you can nap for 15 to 45 minutes.

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Countermeasures That Work

Good Sleeping Environment

Definition and Scope

A good sleeping environment sets the stage for restorative sleep. Although most people can get used to almost any sleep environment, especially when they are exhausted, certain characteristics of where you sleep can enhance or compromise how restorative a rest period is.

Limitations of Use

There may be practical limitations to controlling the physical elements of the sleep environment, especially when traveling. For example, some hotels do not provide room-darkening shades, or outside traffic noise may be unavoidable. However, an individual can prepare for some of these factors by carrying earplugs and eyeshades. It is also important to not invest too much psychologically in the need for certain sleep environment characteristics because this can lead to stress-induced insomnia.

Advantages to Use

The principal advantage to using this countermeasure is that an individual can adapt their sleep environment to meet individual needs, and have a continuing positive effect on sleep quality.

Things to Consider

To ensure that sleep is restorative, sleeping environments must be quiet, dark, and comfortable.

To ensure a quiet environment, the individual should remove any noise sources, especially those that are unpredictable (e.g., pets in the bedroom). Use of earplugs to reduce traffic noise or other external sounds helps many people, as well as the use of a constant low-level noise source such as a fan.

The amount of light in a sleeping area can be reduced by using black-out shades, heavy dark fabric for curtains, or “hurricane shutters” over windows. Some people also use eyeshades in areas where there is substantial light leakage.

Comfort in the sleeping environment is related to the quality of the bed, and the temperature. The bed and pillows should be of appropriate firmness for personal comfort, and the temperature not too warm or too cold.

Two additional environmental recommendations include: orient the clock face away from you so as not to worry about the times especially when having difficulty falling asleep, and use your sleeping area only for sleeping – not other arousing activities such as work or watching TV and videos.

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Countermeasures That Are in the Research Phase

Models of Alertness

Definition and Scope

Using knowledge of the physiological processes controlling alertness to predict your level of alertness on the job.

Limitations of Use

Alertness models are only available to transport workers as "rules of thumb." The research community has not yet produced software tools that can be used with precision by the layman. Also, there are many other variables contributing to momentary alertness levels, such as stimulation level, other countermeasures employed, and individual differences in sleep needs. So, model predictions should be used as guidelines rather than absolute predictions of alertness. In addition, models need to be validated for each particular use. Models developed for one application are all too often generalized for other applications without being validated for that use.

Advantages to Use

Research indicates that level of alertness at any particular point in time is controlled by three basic factors: (1) circadian rhythm (see section 5-2), (2) length of last sleep period, and (3) length of time awake. Specific alertness values can be predicted from knowing where an individual is in their circadian phase, how long they slept during their last sleep period, and how long it has been since they woke-up. The nature of this model conforms to biology and common sense: an individual is naturally sleepy toward the late evening hours, sleeping for 8 hours recovers alertness, and alertness decreases the longer an individual is awake.

Although "plug-in" models to predict alertness are not available at this time, it is possible to use the general nature of these models to predict how an individual is likely to be feeling during a schedule change. For example, if you are going to switch from day to night shifts, it is likely that you will wake up on the first day of your night shift at your usual time, e.g., 0700 hours. Your alertness profile will reflect this, and throughout the day your circadian sleepiness process will increase, so that by the time you go to work at 2300 hours, you will be ready to go to sleep. As you stay awake throughout the night, your alertness will decrease as it follows the circadian rhythm process; there will be no increased value on your sleep recovery process to balance that out.

As you adjust to this new shift over a week, your physiological processes will eventually adapt, so that your alertness level will increase as you are on the job. Using knowledge of how your alertness is affected by your internal physiology will help you to anticipate how you will feel at certain points in time, and to think about other potential countermeasures you might use, such as caffeine or a nap.

Things to Consider

Alertness models are best used to estimate periods of reduced alertness so that specific countermeasure can be identified and used. Additionally, alertness profiles from the models can be used to design work schedules.

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Countermeasures That Are in the Research Phase

Fitness for Duty Testing

Definition and Scope

Fitness-for-duty tests determine if a transportation operator or employee is fit to perform their job at the moment of testing. This means: (1) "testing" when the worker shows up at the workplace to begin an assigned work shift; (2) periodically testing a worker in the middle of a work shift to determine if he/she is still performing with a satisfactory level of alertness; or (3) testing prior to being permitted to work an additional work shift, or doing overtime.

Limitations of Use

A growing number of fitness-for-duty tests are becoming more portable, and now are commercially available. However, many such devices have not been "validated" as fitness-for-duty tests, even though they might be advertised as such. These tests are still in the research stage and must overcome a variety of issues related to practical implementation. For example, most fitness-for-duty tests do not reliably predict whether a worker will perform adequately some number of hours (e.g., 3 to 7 hours) into the future, after passing the "fitness now" test. Additionally, there is no agreement on an acceptable performance level.

Advantages to Use

Fitness-for-duty testing may detect a worker who reports to work already sleep deprived. It attempts to predict "how ready a worker is to perform" within acceptable levels of cognitive alertness, and to predict if good performance can be sustained over the duration of the ensuing work shift. Fitness-for-duty testing is an idea similar to conducting a "drug or alcohol test" to determine if a worker is ready to perform the job.

Things to Consider

Fitness-for-duty tests generally employ short tasks to measure a worker's abilities that would be affected by fatigue. These include:

- Reaction time
- Eye-hand coordination tasks
- Tracking
- Short term memory
- Involuntary eye reflexes such as pupil diameter
- Speed and amplitude of pupil response and saccadic velocity

Having one or more fitness test stations set-up at transportation terminals might permit periodic employee fitness testing before workers begin a work shift.

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Countermeasures That Are in the Research Phase

Alertness Monitoring

Definition and Scope

Alertness monitoring involves tracking the performance or physiological measures of vehicle operators to determine if they are approaching drowsiness or impairment. *Vehicle-based* technologies compare current operator performance on such factors as driver steering-wheel variability, vehicle acceleration, speed variability, braking, gear changing, lane deviation, distances between vehicles, and route navigation against the operator's normal performance. *Operator status* monitors often seek to measure and record, in near real time, some physical or physiological features of the operator's eyes, face, head, heart, brain electrical activity, muscular activity, reaction time, etc.

Limitations of Use

Virtually all of the in-vehicle and physiological monitoring devices are in the research stage. While some devices may be commercially available (from very small and specialized companies), there is not yet sufficient evidence about their reliability and validity to warrant routine use.

Some of the questions that need to be answered include:

- What is "normal" or safety critical "abnormal" variability for these measures?
- What constitutes acceptable performance for equipment operators within a particular transportation mode (e.g., pilots, transit operators, truck drivers, etc.)?
- Could a perfectly safe operator be classified as "unacceptable" on occasions (e.g., score a false positive)?
- What measures are best for providing an "early warning" so that operators have not already gone too far into the impairment zone?

Suitable answers to these and other questions must be developed for each monitoring technology and for equipment operators in each mode of transportation.

Advantages to Use

The utility of either type of in-vehicle monitors is the "self-monitoring and self-management information" concerning the operator's level of alertness or fatigue. Relatively unobtrusive instrumentation can continuously provide the individual with a personal monitor of actual performance in controlling the vehicle, or offer a personal physiologically based alertness index. If the measures exceed criteria for degraded performance, the monitoring systems warns the operator by way of an alerting mechanism (e.g., visual, auditory, vibratory signals) that they look or are acting drowsy at the controls.

Once you gain confidence the technologies can be of assistance in personal alertness monitoring, you can incorporate these features into a set of personal alertness and fatigue management practices to help ensure safe operation of the vehicle, and lessen the likelihood of falling asleep at the controls.

Things to Consider

Integrating combinations of several different monitoring technologies, employing both vehicle performance and operator physiological status indicators, offers the best chance of keeping a transportation equipment operator informed of his/her alertness status and impending fatigue effects on safe vehicle control. A growing number of in-vehicle and operator status monitoring systems are being tested and evaluated commercially and through government sponsored field-testing. When effectiveness in terms of reliability, sensitivity, and validity is attained through formal validation testing, it may prove worthwhile to incorporate that into corporate operator fatigue management programs. Computerized micro-miniaturization of many of these devices will make them affordable.

Developing operator trust in the systems will be an important element of alertness monitoring technologies.

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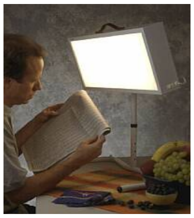
Countermeasures That Require Supervision by a Physician

Bright Light




Definition and Scope

The use of bright light as an operational fatigue countermeasure refers to timing the exposure to outside or bright indoor light in order to shift the circadian rhythm to correspond to a new work schedule, or to enhance alertness.

Limitations of Use

Use of light exposure for resetting the circadian rhythm is a complex undertaking, and should be guided by a person knowledgeable in circadian physiology. Additionally, the benefits of resetting the circadian rhythm can be maintained only through fairly rigid adherence to the procedure, and ensuring that other time cues (e.g., daylight) are minimized. For some workers, this countermeasure may not be feasible because of the need to maintain low light levels in the work environment (e.g., aircraft cockpits or ship bridges).

Use of indoor lighting levels to increase alertness may not be feasible in some work environments where night vision is required. In addition, it is necessary to minimize the exposure to light prior to bedtime so that the individual is not too alert to sleep.

Advantages to Use

One reason that shift workers are sleep deprived is that their circadian rhythms never adjust from that of a day-oriented worker because of the constant exposure to *time cues* such as bright light and social activity. Bright light can be used to increase alertness at times when circadian rhythms would otherwise be at a low point and the individual would be feeling sleepy, such as in the middle of a night shift.

By using bright light exposure to shift circadian rhythms to work schedule requirements, individuals will get more sleep and feel more alert when they are on the job. This countermeasure can be particularly useful for pilots and other transport workers who rapidly shift through multiple time zones, and for those who work on a forward rotating schedule that changes by one shift each rotation (e.g., day shift, afternoon, night). There are also approaches that can be used for permanent night shift workers.

Things to Consider

In order to shift the circadian rhythm using bright light and controlled dark exposure, an individual needs to determine whether he/she wants to *advance* or *delay* his/her rhythm. Advancing the rhythm means shifting it so that the low point in the daily cycle (as measured by body temperature) occurs earlier, whereas delaying the rhythm means shifting it so the low point occurs later. Advancing the rhythm will make the day seem shorter – the individual will feel sleepy earlier, while delaying the rhythm will extend the day and the individual will be able to stay up later.

Advancing the circadian rhythm allows an individual to adjust to eastbound travel, for example, or to an earlier schedule. Delaying the circadian rhythm allows adjustment to westbound travel, or a later schedule. In general, if an individual is exposed to light following the low point in his/her rhythm it will advance, making it easier to go to sleep earlier and wake up earlier. In contrast, if an individual is exposed to light before his/her low temperature point, the rhythm will delay, making it easier to work and sleep later. In practice this means exposure to light during the first part of a night shift to delay the rhythm, or exposure to light prior to normal wake up time, if an individual is a day worker, to advance the rhythm.

The light exposure we are talking about is in the range of 3000 to 10000 lux – much beyond that obtained simply from indoor lights. Special equipment is required to generate this level of illumination, and some evidence suggests that the green wavelength is especially effective. Using light exposure for several hours over a period of several days is usually most effective in shifting the circadian rhythm, although periods as short as 30 minutes have been shown to have an effect.

In addition to *light* exposure, it is also important to control the timing of *darkness*. This is especially true for those workers who may be traveling between work and home in the bright morning sun. In these cases, it is important to minimize exposure to the sunlight by wearing dark glasses (special goggles are recommended), and to ensure that your sleeping quarters are blacked out.

Exposure to indoor-lighting levels for several hours during the early part of the night (e.g., prior to bedtime) can also promote alertness, and with greater alertness at higher light intensities. This countermeasure can be used in addition to light exposure, or by itself to shift your circadian rhythm. This is a particularly good countermeasure to use if you have the flexibility in your work environment to control the lighting level.

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Countermeasures That Require Supervision by a Physician

Stimulants

Definition and Scope

The use of synthetic or natural drugs to reduce the effects of sleep loss and enhance alertness.

Limitations of Use

Even under the guidance of a physician, stimulants can have unwanted and dangerous side effects, including changes in blood pressure and pulse, headaches, irritability, appetite loss, insomnia, nervousness, talkativeness, and sweating. Extreme reactions include hallucinations and paranoid psychosis.

Prescription stimulants are not generally permitted in operation of public transportation vehicles in the U.S. and many other industrialized nations. Randomized drug testing is regularly carried out to cut down on the usage of most known stimulants, at the threat of loss of job.

Stimulants have a high potential for addiction and abuse because of the rapid euphoria that results from high doses. This can lead to a cycle of binging and crashing, and long-term abuse can lead to mental and behavioral disorders.

Finally, possession and use of controlled substances without a proper physician's prescription is illegal, and could result in fines and jail time.

Advantages to Use

Stimulants exert a physiological effect on your nervous system so that the effects of sleep loss can be temporarily reduced. Caffeine (discussed in a separate entry) is an example of a stimulant – one that does not require a prescription, and that does not have adverse side effects unless consumed in very large quantities.

Stimulants are particularly useful to the small population of individuals who suffer from narcolepsy or other debilitating sleep disorders. Military personnel sometimes use stimulants during sustained operations, although this practice has recently been questioned.

The effects of prescription stimulants such as dextroamphetamine and modafinil are clear-cut – alertness is increased and performance is enhanced, relative to sleep-deprived individuals. These effects are also observed with a number of over-the-counter decongestants containing pseudoephedrine, and herbal stimulants such as ephedra.

Things to Consider

Synthetic stimulants such as amphetamine and modafinil are controlled substances and should only be used under the guidance of a physician for treatment of a specifically debilitating sleep disorder.

Herbal stimulants are unregulated, and the effects of many are unknown because of lack of proper evaluation. However, it is known that ephedra in particular is associated with heart attack and stroke, and is likely to soon be controlled. You should consider all herbal stimulants as unproven and a safety hazard. Decongestants are not designed for increasing alertness – this happens as a side effect, along with increased drying of mucous membranes.

Following is a list of medically prescribed stimulants:

- Methylphenidate
- Dextroamphetamine
- Methamphetamine
- Pemoline
- Mazindol
- Levo-amphetamine
- Fencamfamin
- Modafinil

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Countermeasures That Require Supervision by a Physician

Sedatives/Hypnotics

Definition and Scope

The use of synthetic or natural drugs to promote sleep when schedule changes interfere with falling asleep.

Limitations of Use

Depending on the specific type of drug class, there are changes in the nature of an individual's sleep although the significance of these changes is unknown. The overall amount of sleep does not change.

It is possible to develop a dependence on hypnotics if used for a long period of time, and there is often a "rebound insomnia" in which sleep is slightly worse for 1 or 2 nights after discontinuing the drug even if used for only short periods of time.

If the drug is a particularly long-acting one, or if the individual has high sensitivity, there may be a "hangover" effect the next day where the individual may feel sluggish.

Advantages to Use

If a worker has a sudden change of schedule that interferes with their ability to go to sleep, there are drugs and herbal substances that can be used to promote sleep. Hypnotic drugs such as Halcion and Restoril are part of a class of drugs that are useful for inducing sleep. These drugs reduce the amount of time required to fall asleep, improve ability to stay asleep, and can maintain sleep for 7 to 8 hours.

Herbal remedies such as Valerian root, chamomile, kava, and lavender are promoted as sleep aids, but the evidence for their effectiveness is much less clear.

Sedatives and hypnotics have the advantage of being applicable to a number of situations that might interfere with sleep, such as shift changes, jet lag, or stress-related short-term insomnia. The drugs can help to alleviate these short-term problems and be discontinued to preclude the risk of dependency.

Following is a list of the most well-known non-barbiturate hypnotic sedatives by their trade name:

- Ambien
- Dalmane
- Doral
- Halcion

- ProSom
- Restoril
- Sonata

Things to Consider

If you want to use hypnotics to help you get to sleep, you should make sure you are doing everything else possible before resorting to drug treatment. This includes ensuring that your sleep environment is appropriate, and that caffeine or exercise is not interfering with sleeping.

You should use hypnotics only by prescription from a physician, and only for as long as necessary to “get over the hump” of sleeplessness, and this should be the lowest clinically indicated dose for as short a time as possible. You should consider the hypnotics as an aid to achieve sleep schedule re-adjustment, instead of a necessity for getting to sleep.

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Countermeasures That Require Supervision by a Physician

Melatonin

Definition and Scope

Melatonin is a hormone produced by the pineal gland in the brain, which increases during the evening and night hours. Synthetic or natural melatonin is used to induce sleepiness and may adjust the circadian rhythm to new schedules.

Limitations of Use

The Food and Drug Administration does not regulate the sale of melatonin, so the quality of products available in health food stores and other outlets is uncertain.

Because use of melatonin can cause drowsiness, it should not be taken if an individual intends to drive or engage in other complex or potentially dangerous activity.

The sleep inducing effects of melatonin are temporary, so while an individual may be able to get to sleep at an unusual time by using melatonin, they may not be able to stay asleep for as long as desired. Additionally, various side effects of melatonin have been reported, including worsened fatigue, depression, coronary artery constriction (possibly increasing heart attack risk), and possible effects on fertility. For these reasons, it is important to only use melatonin under the guidance of a properly trained physician.

Advantages to Use

Melatonin in small doses (0.3 to 5 mg) has rapid sleep inducing effects, and lowers alertness and body temperature following administration. When combined with proper timing and light exposure, melatonin can help to adjust the circadian rhythm to a new schedule, and reduce the effects of fatigue and jet lag.

Things to Consider

The timing of melatonin is an important factor – it needs to be taken in the proper relationship to the body's biological rhythm in order to achieve the desired effect. It is easiest to use melatonin to *advance* the rhythm, that is, to speed up an individual's body clock so that they will go to sleep earlier and get up earlier. In order to do this, melatonin should be taken well before the low point of an individual's circadian rhythm. For example, air travelers from the west coast who need to adapt to East Coast time might take melatonin around 2100 Eastern Standard Time in order to promote sleep at a time when they would otherwise be wide-awake.

Using melatonin to *delay* the circadian rhythm is somewhat more complicated because of the interaction with daylight, which is a much more powerful adaptation mechanism.

In either case, the use of melatonin should be guided by a physician who specializes in circadian physiology and the use of melatonin for treating circadian rhythm adaptation disorders.

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Countermeasures That Do Not Work, Have Minimal Effects, or Cause Health Problems

Nicotine

Definition and Scope

Use of nicotine through smoking, nicotine patches, or other means to maintain alertness.

Limitations of Use

The adverse health effects of nicotine, especially from tobacco use, far outweigh the small alerting effects obtained. Additionally, nicotine reduces the quality of sleep when consumed within several hours of bedtime. Because of the addictive nature of nicotine, the detrimental health effects, and its interference with sleep, we recommend against any use of this substance.

Advantages to Use

Nicotine is a stimulant that has effects on performance and mood similar to that of caffeine; that is, it enhances alertness for a period of time following consumption.

Things to Consider

The alerting effects of nicotine use occur relatively quickly compared to caffeine, which takes approximately 30 minutes to enhance alertness. The duration of nicotine in the bloodstream is approximately 2 hours. This should not be interpreted as meaning that the alerting effect will last 2 hours, because the effects of nicotine are quite dose dependent, with large individual differences in reaction depending on how frequently nicotine is used.

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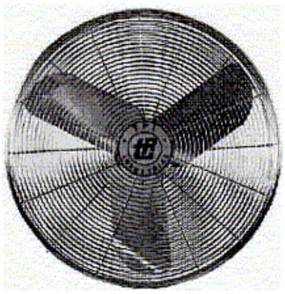
Countermeasures That Do Not Work, Have Minimal Effects, or Cause Health Problems

Ventilation and Temperature



Definition and Scope

Changing airflow and temperature in the surrounding environment to increase alertness.

Limitations of Use

While there may be a brief effect of lowering the surrounding temperature or increasing airflow, research data suggest that the impact is very short, and not likely to increase alertness for longer than a few moments. So, if an individual is feeling sleepy, it is best to use another countermeasure.

Advantages to Use

Altering the airflow and temperature in the surrounding environment is fairly easy for most transportation operators, through control of air conditioning or increasing fresh air by opening a window.

Things to Consider

It is important to ensure that the air quality in the immediate operational environment is good, since fatigue is one of the symptoms often associated with impurities in the air. The fatigue that results from impurities is a physiological reaction to reduced oxygen, and an indication that the environment should be changed. For transportation operators, these impurities might result from improperly ventilated exhaust systems or toxic cargo that is leaking.

Temperature tends to affect alertness indirectly, by increasing the overall comfort level. So, if an individual is inclined to feel sleepy anyway, a warm environment may increase those feelings. However, the opposite is not true – there is little benefit to opening a window or lowering the temperature if an individual is already fatigued.

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Countermeasures That Do Not Work, Have Minimal Effects, or Cause Health Problems

Exercise

Definition and Scope

The use of physical exercise to shift circadian rhythms, increase alertness on the job, and to promote good sleep.

Limitations of Use

While exercise will promote health and improve an individual's sleep, it does not permit them to cut back on primary sleep. Exercise can reduce immediate feelings of fatigue resulting from schedule changes and sleep deprivation, but that feeling only lasts for about 30 minutes. The effects of exercise on job performance are complex, and tend to wear off quickly, possibly even making performance worse in the afternoon. So, while an individual may feel better after exercising during a sleepy period on the job, they are still fatigued and should be aware that performance is likely to be compromised.

Do not exercise too close to bedtime, because increases in body temperature and alertness will make it difficult to go to sleep.

Advantages to Use

Physical exercise has the principal benefit of improving overall cardiovascular health and muscle tone. Additionally, regular exercise improves sleep – individual's fall asleep quicker and sleep more soundly.

Research suggests that physical activity can shift the circadian rhythm forward or backward depending on the timing of the exercise. It is likely that changing the timing of regular physical exercise, along with other time cues such as exposure to light and timing of meals can help shift circadian rhythm to a new work schedule.

Physical exercise can also be used to reduce the feeling of fatigue resulting from not getting enough sleep. Research indicates that brief periods of exercise can reduce feelings of sleepiness, although job performance does not improve. In rested individuals, a morning exercise break may improve alertness and driving performance for a brief period afterwards.

Things to Consider

The health benefits of regular physical exercise are clearly established, and individuals should consider initiating a regular program of exercise or maintaining what they are already doing. If they work irregular hours or in situations that limit what they can do (e.g., no ready access to a gym, or darkness), planning ahead and the use of alternative activities such as walking can be used to maintain a healthy activity level.

Regular exercise will contribute to feelings of increased energy, by helping develop stamina and improving your sleep. It should be a regular part of a healthy lifestyle as well as a primary fatigue countermeasure.

Because exercise can move the circadian rhythm, the timing of exercise is very important. If an individual wants to delay sleep, exercising just prior to bedtime will tend to delay their rhythm. Alternatively, if an individual wants to go to sleep earlier, as in east-west travel, exercising several hours before they intend to go to bed will advance their rhythm.

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Countermeasures That Do Not Work, Have Minimal Effects, or Cause Health Problems

Foods

Definition and Scope

Varying meal content in order to increase alertness or promote sleep.

Limitations of Use

An attempt to extend an individual's endurance or promote sleep by altering the content of meals is unlikely to succeed. It is better to focus on consuming a nutritionally healthy, and balanced diet at the appropriate times of day.

Advantages to Use

The physical activity associated with eating can itself induce an alerting effect, however current research evidence suggests that specific food content has little, if any impact on level of alertness or feelings of sleepiness.

Things to Consider

Getting a balanced, nutritious diet at appropriate times is often difficult for transportation operators. Schedules often limit eating to what is available when time and work permit.

Individual's can avoid this situation with appropriate planning. Packing meals prior to leaving home, taking rest stops where supermarkets are located, and purchasing boxed meals from hotels are some steps that can be taken to provide the right foods are available when needed.

Whenever possible, individual's should try to eat meals at times that correspond to their normal meal times – this will help maintain a regular sleep-wake cycle, since meals are a time cue that influence circadian rhythms.

Consuming large meals prior to sleep can disrupt the subsequent sleep period and result in gastrointestinal discomfort.

Foods such as potatoes, rice, dairy products, turkey, fruits containing glucose, and sugar speed the amino acid tryptophan to the brain where it is converted to serotonin, a neurotransmitter that induces sleepiness.

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Countermeasures That Do Not Work, Have Minimal Effects, or Cause Health Problems

Sound

Definition and Scope

Using sound from sources such as the radio, tapes, or compact discs to maintain alertness.

Limitations of Use

This countermeasure reduces the effects of fatigue for a very brief period. If an individual is already sleepy, the countermeasure may have little, if any effect. Although the brief alerting sound may seem to reduce fatigue, performance will continue to deteriorate.

The best use of sound is to provide “company” while the individual arranges to take a break – it is not a substitute for sleep.

Advantages to Use

Turning on the radio or a sound device in the car or other location where the individual is working is a simple way to change a monotonous environment, and the change may reduce fatigue or prevent falling asleep for a brief period of time.

This countermeasure briefly increases the physiological arousal level by adding stimulation to the environment.

Things to Consider

If an individual is getting tired on the job, using this countermeasure may be a useful means to perk-up for a few minutes until he/she can find an opportunity to pull off the road, or take a break.

Having a passenger or co-worker to engage in conversation is another means to increase stimulation.

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Countermeasures That Do Not Work, Have Minimal Effects, or Cause Health Problems

Odor/Fragrance

Definition and Scope

Use of aromatherapy with scents such as peppermint or lavender to stimulate alertness or promote sleep.

Limitations of Use

Using a countermeasure that does not work is probably worse than not using one at all. People in aromatherapy studies tend to rate themselves as more alert after being exposed to an aroma, but their performance does not change – so they are actually fooling themselves into thinking that aromatherapy works.

Advantages to Use

There is no scientific evidence that administering a fragrance will enhance alertness, increase performance, or promote sleep.

Things to Consider

If an individual is feeling fatigued during transportation operations, another countermeasure should be used.

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Countermeasures That Do Not Work, Have Minimal Effects, or Cause Health Problems

Over-the-Counter Sleep Aids

Definition and Scope

Using non-prescription medications to promote sleep.

Limitations of Use

Since there is less scientific evidence regarding the sleep promoting effects of over-the-counter (OTC) drugs, and there are documented performance degradations and hangover effects, we do not recommend their use.

Advantages to Use

Many people use OTC products to try and promote sleep; the primary advantage being that they are available without a prescription. Examples of such products include Alka-Seltzer PM, Sominex, and many others.

Things to Consider

The principal ingredient in most of the OTC sleep aids is diphenhydramine (Benadryl), which is an antihistamine. These drugs do appear to have a sedating effect, although they have not been well-studied because of their unregulated status.

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5. Sleep Basics

How to Use This Section

The information here is organized as a set of individual topics that can be read sequentially or separately, depending on reader need. The reader will get the best understanding of how alertness and fatigue result from sleep and brain physiology if the sections are read sequentially. The individual sections can then be used as reference material if questions arise later.

The reader can also copy or adapt the contents in each of these topics when developing educational materials to increase understanding of the basics of sleep and alertness management.

Introduction

Everyone knows how it feels to get too little sleep. Many people refer to this feeling as "fatigue" or "sleepiness" – feeling less alert, sometimes exhausted, tending to crave sleep, and nodding off. The information in this section of the handbook talks about the basis for alertness, that is, getting adequate sleep. We also talk about the opposite situation – not getting adequate sleep, some of the reasons why this happens, and how it affects the level of fatigue and alertness.

Sleep is based on brain physiology and humans have specific requirements for getting adequate sleep. It is easier to sleep at certain times of the day than others because of brain mechanisms that have evolved over millions of years. The basic information in this section will help clarify why it is necessary to get adequate sleep, why we sometimes don't, when a person might start feeling fatigued and how it affects him/her on the job, and what he/she can do to make sure he/she gets adequate sleep.

Overview of Sleep Basics Topics

The following topics are discussed in the remainder of this section:

- Circadian Rhythms
- Sleep Cycles
- Fatigue, Alertness, and Sleep Loss
- Causes of Sleep Loss
- Getting Adequate Sleep – How to Do It

Circadian Rhythms

The term "circadian rhythm" refers to the daily fluctuations in physiological and psychological functions controlled by the brain's biological clock. "Circadian" is a term from the Latin roots *circa* meaning "about" and *dies* meaning "day." The normal human sleep-wake cycle is based largely on the circadian rhythm, as well as alertness throughout the day. The brain mechanism that controls the circadian rhythm is located in the suprachiasmatic nucleus of the hypothalamus (Figure 5-1).

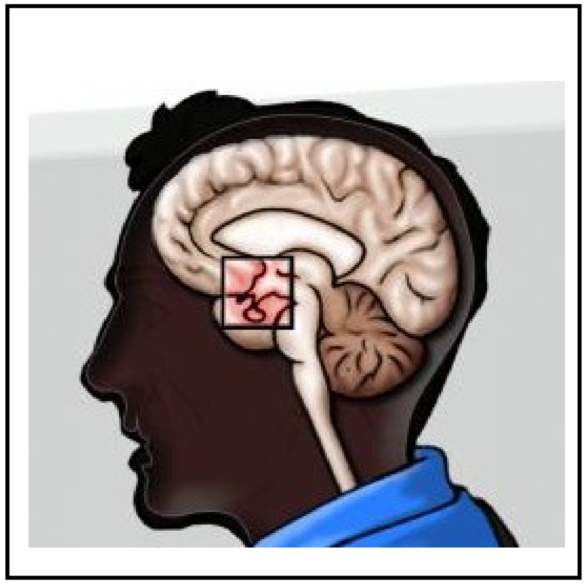

Figure 5-1. Location of the brain's biological clock that controls circadian rhythms.

The brain's biological clock serves as a pacemaker for numerous daily cycles, including sleeping and waking, hormone secretion, digestion, body temperature regulation, performance capabilities, and mood. The biological clock programs humans to operate on a 24-hour clock so that we are sleepy at night, and awake during the day. Also, during daily awake hours, the circadian rhythm leads to predictable changes in alertness, such as the tendency to feel sleepy at some point during the afternoon (this is sometimes referred to as the "post-lunch dip," although the alertness drop has little to do with whether you have eaten). Figure 5-2 illustrates the circadian rhythm in several physiological and psychological functions; it is noteworthy that when alertness is lowest, i.e., between 2400 and 0500 hours, melatonin levels are the highest – this is because secretion of melatonin by the brain leads to sleep onset. An individual's circadian rhythm is sensitive to external time cues, such as the level of sunlight and patterns of activity in the environment.

Circadian rhythms are important to alertness management because they represent what the body was *designed* to do – sleep at night and be awake during the day. Work schedules that require people to be awake at night and asleep during the day are challenging primarily because of the circadian rhythm. The biological clock can adjust to different schedules or time changes, but this takes a certain amount of time, depending on how extreme the change is. Jet lag, for example, is a situation where the individual's rhythm is different from that of the local environment. After a few days in the new time zone people adapt. It is much more difficult, however, for people to adapt to work schedules that are opposed to their circadian rhythm because the normal pattern of light and dark, and daily activities are the same – they do not change as they do with a time zone shift. Shift workers often switch from one activity-rest pattern to another, as on weekends, and their circadian rhythm becomes chronically misaligned with local time.

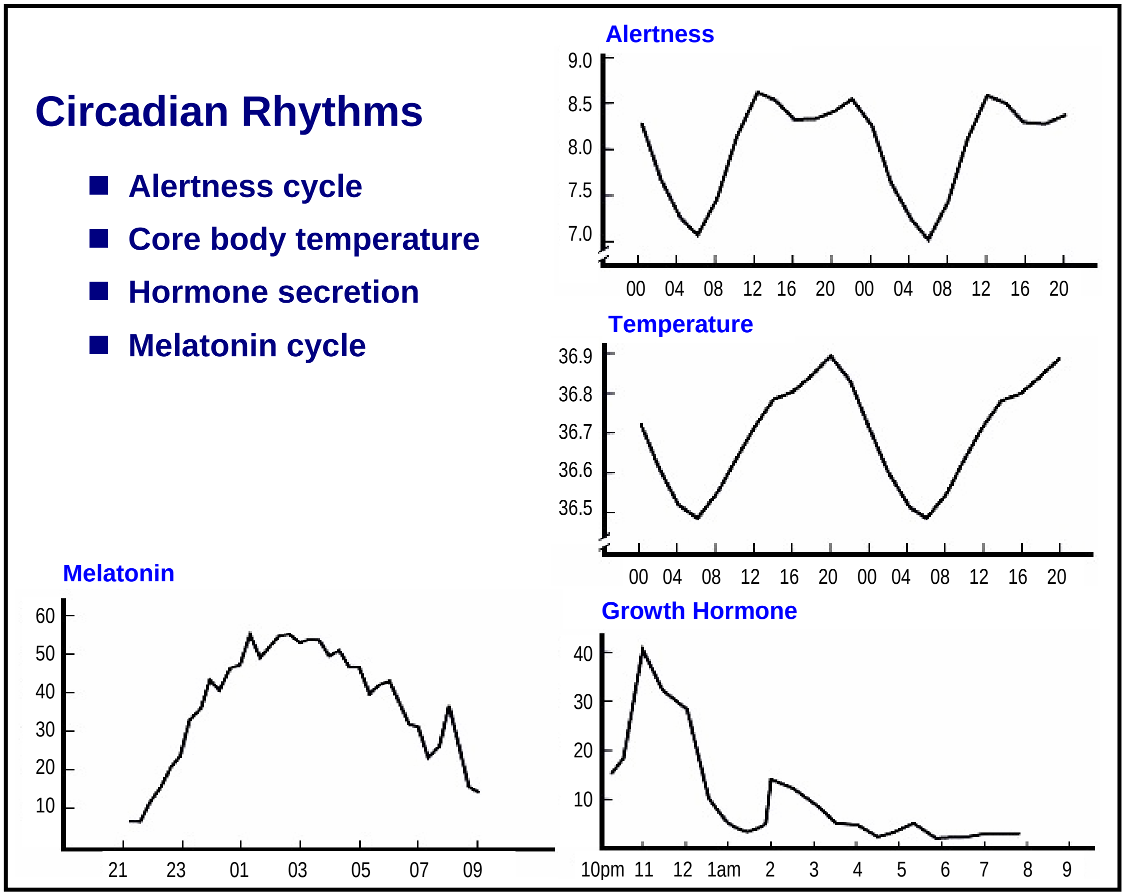

Figure 5-2. Circadian rhythms for different physiological and psychological functions.

When the circadian rhythm is not completely adapted to a person's work-rest schedule, on-the-job alertness is affected. This is because the individual is working when the brain is programmed to sleep, and may not be getting adequate sleep during off-work periods because of brain programming for wakefulness. This creates a chronic problem of sleep loss and low sleep quality, which further affects job performance and alertness.

Circadian Rhythms – Key Points

- The daily cycle of sleeping and waking is controlled by a biological clock in the brain.
- Circadian rhythms affect alertness during the day.
- The biological clock is sensitive to external time cues such as light and social activity.
- Humans are programmed to sleep at night and be active during the day.
- Shift work opposes the circadian rhythm, leading to problems of sleep loss and low alertness.
- The circadian rhythm can be changed but it is difficult in the presence of strong time cues.

Sleep Cycles

Sleep is a basic physiological need. Most people need about 8 hours of sleep per night, although some may need as little as six hours, while others may need 10 hours. On an individual basis, the amount of sleep a person requires is that amount necessary to achieve full alertness and effortless functioning during the waking hours, even when sitting quietly and being bored. When an individual feels that they must keep moving to stay alert, that is strong sign that they are not getting sufficient sleep.

Sleep is a physiological process that can be monitored by brain electrical activity. As a person relaxes from their waking state, brain electrical activity slows progressively, until the deepest level of sleep (Stage 4) occurs. Figure 5-3 illustrates the various stages of sleep, which progress through a cycle that repeats throughout the night.

As a person drifts off to sleep, he/she enters Stage 1. This is followed by a slowing of the heart rate and relaxing of muscle tension as Stage 2 is entered. In Stages 3 and 4, slow wave brain activity is associated with very deep and restorative levels of sleep. During these stages it is particularly difficult to wake the person. Rapid Eye Movement (REM) sleep occurs throughout the cycle and shows a brain activity pattern similar to Stage 1 or waking; this sleep stage is associated with dreaming.

Classification of Sleep

- **Awake**
- **Sleep**
  - **REM**
  - **Light**
  - **Deep**

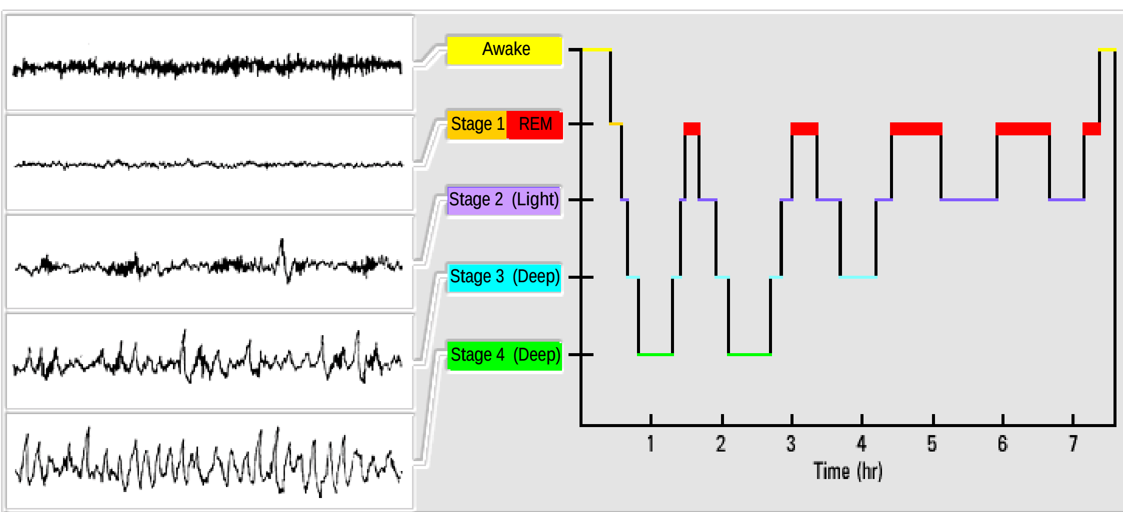

Figure 5-3. Brain electrical activity (on left) illustrates the stages of sleep (on right), which progress in a cyclic fashion through the sleep period.

When people take a nap during the work day for about an hour or more, they are likely to fall into the deeper stages of sleep (Stages 3 and 4) and when they awaken from such deeper sleep, they are likely to experience “sleep inertia,” which is grogginess that can last up to 15 or 20 minutes. To gain the benefits of a nap during the work day, and to avoid such sleep inertia, it is suggested they take a nap for 45 minutes or less, as this decreases the risk of falling into the deeper sleep stages and having the inertia upon awakening.

With respect to a person's principal sleep for a 24-hour period, it is important that the entire cyclic process of sleep be completed in order to receive the restful effects of a sleep period. Anything that interferes with sleep, such as noise disruptions, medication, alcohol, or simply insufficient duration, will change the physiological structure of the sleep cycles and impair alertness the next day.

Sleep is affected by aging. Although older people need as much sleep as younger people, they sleep less soundly and experience more awakenings during the night and shifts from one sleep stage to another. Medical conditions common in older folks make sleep disruptions more likely. A prime result of sleep disruptions is increased daytime sleepiness and more napping during the day – which paradoxically can affect the quantity and quality of night time sleep.

People also differ from one another in their preferred activity and sleep times. “Larks” tend to be “morning people,” arising early and getting to sleep early. “Owls” tend to stay up later at night and arise later in the morning. Owls tend to perform better on afternoon and evening shifts. People usually fall somewhere on a scale between being a total lark or owl.

Sleep Cycles – Key Points

- Sleep is a basic physiological need.
- Sleep is a complex process consisting of multiple stages, some “deeper” and more restful than others.
- Rapid Eye Movement (REM) sleep occurs throughout the night and often involves dreaming.
- Upon awakening, people experience temporary grogginess called “sleep inertia” which usually disappears in 15 minutes.
- Anything that interferes with the duration or cyclic structure of sleep will reduce alertness the next day.
- Aging is associated with increased sleep disruptions leading to daytime sleepiness.
- People differ in their preference for early or late schedules (larks vs. owls).

Fatigue, Alertness, and Sleep Loss

When people do not get adequate sleep, they experience fatigue and loss of alertness during the time they are awake. This affects their ability to perform safely on the job. Sleep loss of even 1 or 2 hours can significantly degrade alertness and performance, with greater effects for increasing amounts of sleep loss.

If a person loses sleep over successive days, this can lead to an accumulated *sleep debt*. For example, if someone who needs 8 hours of sleep only gets 5 hours a night over 4 nights (i.e., over four 24-hour days), he/she would accumulate a sleep debt of 12 hours. This can result in a cumulative effect on alertness and performance over that period of time. Frequently, we tend to gain some recovery sleep over our "weekends" or our 2 days off from work. However, recuperation from sleep debt requires getting more sleep for at least several nights. The effects of large sleep debts, say not sleeping for 2 days, can still be detected in performance levels after a week of sleeping normally for 7 to 8 hours per night.

Chronic sleep loss can contribute to health consequences, including obesity, diabetes, and high blood pressure. Even young people who experience sleep debt over a week show increased likelihood of infection and stress effects. Shift workers commonly experience sleep loss and are more prone to gastrointestinal disorders, as well as aggravations of cardiovascular disease and diabetes.

If there is enough reduction in sleep, people will reach a level of critically reduced alertness in which sleep spontaneously intrudes into wakefulness. These uncontrolled sleep episodes (microsleeps) can occur even when a person is standing up or operating equipment. It is important to recognize the signs and symptoms of fatigue, and to ensure that workers are getting sufficient rest to maintain alertness on the job.

Signs and Symptoms of Fatigue

- Forgetful
- Poor decision making
- Slowed reaction time
- Reduced attention
- Poor communication
- Fixated
- Apathetic
- Lethargic
- Bad mood
- Nodding off
- Itchy eyes
- Need to sit

Causes of Sleep Loss

One of the main causes of sleep loss is *shift work*, i.e., working during hours outside the normal daylight routine. Figures 5-4a and 5-4b show the typical pattern of day work, and night rest. This pattern is altered, or sometimes reversed for shift workers, and can lead to difficulties sleeping. The primary reason for sleep loss in shift workers is that they are trying to sleep at times when the brain's biological clock mechanism signals that they should be awake. As a consequence, shift workers may find it more difficult to go to sleep, or to sleep as long as they wish.

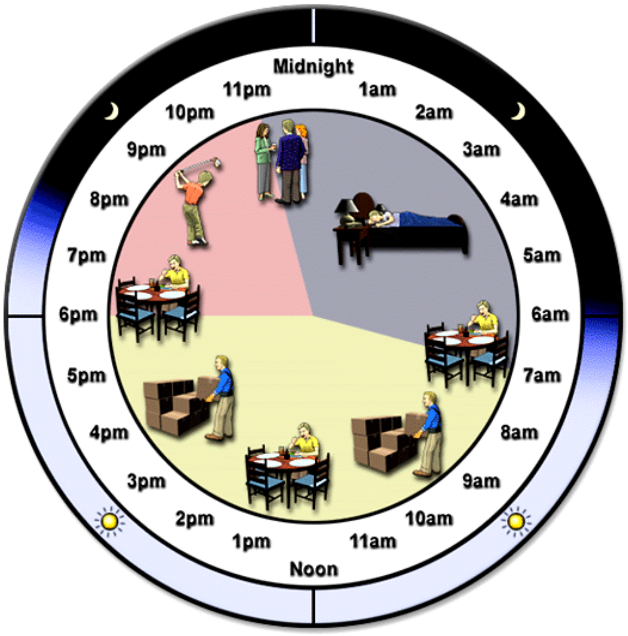

Figure 5-4a. The normal daily routine for sleep and work.

Social and family demands can contribute to the sleep loss problems experienced by shift workers, because they may choose to spend more time in these activities at the expense of trying to rest. Many people who work afternoon or night shifts revert to a normal daytime schedule on the weekends or days off, in order to synchronize with the world-at-large. This can lead to a constant state of "circadian desynchronization" in which the body and the daily clock are in conflict.

A number of substances can interfere with sleep, including caffeine, alcohol, and over-the-counter drugs such as decongestants. The effects of caffeine typically last for about 4 to 5 hours, but may last up to 10 hours in especially sensitive individuals, so a cup of coffee after dinner may well interfere with getting to sleep. Similarly, alcohol may initially relax a person and assist in getting to sleep, but as it is metabolized there will be a "rebound" alerting effect, causing a person to awaken more easily. Alcohol also interferes with

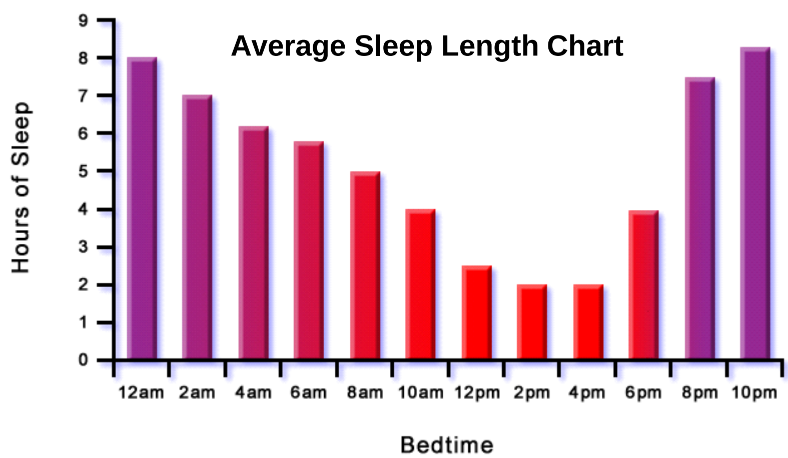

Figure 5-4b. Sleeping at times not favored by the brain's biological clock results in less sleep.

REM sleep. Nasal decongestants interfere with sleep because they contain pseudoephedrine, which is a stimulant.

Other activities that may interfere with sleep include eating and exercise. Consumption of specific foods can stimulate gastrointestinal reactions that may result in discomfort and sleep problems. Exercise on a regular basis is good for promoting sound sleep, but should not be done within an hour or two of bedtime, because it has an alerting function and can shift the biological clock forward.

Specific sleep disorders also result in sleep loss. Among the most common of these are medical conditions such as congestive heart failure and arthritis that lead to the symptom of *insomnia* (i.e., difficulty in getting to sleep or staying asleep). The condition, *sleep apnea,* affects as many as 5 out of every 100 people and is a breathing disorder involving periodic interruptions of breathing during sleep. Key signs that a person has sleep apnea are reports from others that the person snores loudly and irregularly when sleeping. Medical specialists can be consulted to determine if a specific condition exists that is interfering with sleep, and proper medical interventions can help to alleviate the problem.

Causes of Sleep Loss – Key Points

- Shift work causes conflicts between the brain's biological clock and when a person works and sleeps.
- Daytime sleep periods result in less sleep because of the influence of the biological clock, and family/social demands.
- Caffeine, alcohol, and over-the-counter decongestants interfere with sleep.
- Food or exercise too close to a sleep period can result in sleep loss.
- Specific sleep disorders, such as insomnia or sleep apnea, cause sleep loss.

Getting Adequate Sleep – How to Do It

The demanding world we live in makes getting adequate sleep challenging. But knowledge of some basic information and approaches can help people make the most of their rest periods to obtain sufficient sleep so they will be alert on the job.

There are four basic areas to consider for ensuring that a person gets adequate sleep:

1. The personal sleep cycle
2. Sleep environment
3. Relaxation
4. Things to avoid

Understanding the individual sleep cycle is crucial for taking the steps to ensure sufficient restorative sleep. People can determine their optimum sleep amount by recording their sleep start and stop times on their third consecutive day off when they are not using an alarm clock to wake up. This is most likely to occur when you take a vacation.

The amount of sleep needed should be enough to feel refreshed and healthy the next day but not more – this will usually be between 7.5 and 8.5 hours. Based on the amount of sleep needed, people should establish a habitual time for going to sleep and waking up, and maintain this schedule whether or not it is a workday. Additionally, daily exercise helps to promote sounder sleep.

The sleep environment should be quiet and dark, using room-darkening shades if necessary. Earplugs can be helpful if there is noise. The temperature of the sleeping room should be around 65° F, and the bed should be used only for sleeping – not for activities such as reading or watching television.

Relaxation can promote falling asleep. The most basic technique is for the individual to wait until feeling sleepy before going to bed. If the individual is not tired, he/she should do something quiet and relaxing like reading or watching TV in dim light until he/she feels sleepy. Once in bed, if he/she cannot sleep, it is best to get out of bed and do some quiet activity until you feel sleepy.

Getting good sleep depends on knowing what to avoid prior to sleeping. Especially important to avoid is caffeine – this should be avoided within about 5 or 6 hours of going to sleep, since the effects can last that long. It is also important to avoid drinking alcohol within 3 hours of bedtime, since alcohol fragments sleep and makes it less restorative. Cutting down or eliminating nicotine is important for promoting good sleep. It is also important to try to avoid thinking about the day's problems – possibly by writing "to do" lists for the next day to clear the mind. Drinking fewer fluids before going to sleep will reduce awakenings to use the bathroom. Finally, a nap should be taken during the day only if there is no trouble going to sleep at night.

Getting Enough Sleep – How to Do It: Key Points

- Make bedtime and waking a routine schedule to get the amount of sleep necessary.
- Ensure the environment is dark and quiet, and not too warm.
- Relax prior to bedtime; don't toss and turn – get out of bed and do something quiet until sleepy.
- Avoid caffeine and alcohol prior to bedtime, eliminate nicotine, drink fewer fluids to reduce use of bathroom, and avoid thinking about problems.
- Nap during the day only if it does not interfere with going to sleep at night.

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Additional Information Sources

This section provides references to fatigue-related information that were not cited in the main body of this document, but would be useful to those interested in a specific aspect of fatigue management. These references are alphabetized within eight general topics, listed below and at the beginning of each topic.

1. Fatigue-Related Job Performance and Accidents
2. Fatigue Modeling and Prediction
3. Alertness Monitoring Research
4. Regulatory Review and Guidance
5. Fatigue Contributing Factors
6. Fatigue Management Program Guidance
7. Fatigue Management Countermeasures
8. Fatigue Management Outcome Research

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Glossary

Alertness - the optimal activated state of the brain. A heightened state of physical and mental readiness that is optimal for an individual to perform functions. Alertness is a dynamic state and may vary from second to second.

Arousal - a change in an individual from sleep to awake. Partial arousal refers to the transition from a deep sleep stage to a lighter sleep stage. Full arousal is when an individual is fully awake and cognizant.

Awake – individual is conscious and aware of their surroundings.

Biological Clock – a bundle of nerves in the brain that regulates the timing of biological functions, including the daily fluctuations in alertness. Also referred to as the internal clock or circadian clock. The biological clock regulates and maintains the circadian rhythm.

Circadian Disruption – a disturbance of the circadian rhythm that can result from flying across multiple time zones, working irregular schedules, working at night, or exposure to light at irregular times of day.

Circadian Rhythm – *circa* translates as “around or about” and *diem* translates as “day”, so circadian rhythms are biological rhythms that have a period of approximately 1 day (24 hours).

Deep-draft Vessels – vessels that typically operate in open-ocean and deep waters.

Fatigue – a condition of degraded capacity to perform physical or cognitive functions due to overexertion, or insufficient or poor quality sleep.

Fatigue Management – activities designed to identify and control factors (environmental, organizational, regulatory, and individual) that contribute to fatigue.

Long-haul Operations – operations that typically require being away from home continuously for multiple days.

Main Sleep – period when an individual gets the majority of their daily sleep.

Melatonin – a hormone produced by the pineal gland in the brain that is a biological marker for the onset of sleep

Phase Advance – the movement of the circadian rhythm to an earlier orientation. If an individual typically gets up at 0800 and begins getting up at 0500, the circadian rhythm will phase advance.

Phase Delay – the movement of the circadian rhythm to a later orientation. If an individual typically gets up at 0500 and begins getting up at 0800, the circadian rhythm will phase delay.

Shift-lag – a condition similar to jet-lag where irregular or rotating work schedules disrupt circadian rhythms similar to flying multiple time zones.

Sleep Debt – a condition, where person gets less than his/her biological sleep need, that can result in fatigue and sleepiness.

Sleep Hygiene – the conditions and practices that promote good sleep. These include regular sleep timing, limiting alcohol and caffeine before sleep, controlling noise, light and temperature, and good quality bedding.

Sleep Inertia – a feeling of lethargy immediately after awakening from sleep or a nap.

Sleep Latency – the length of time it takes to fall asleep.

Tryptophan – an amino acid that is converted to serotonin, a sleep-inducing neurotransmitter

Rotating Work Schedule – work schedules that vary. Schedules can vary daily, weekly, or monthly. *Forward or clockwise rotations* - go from day, to afternoon/evening, and end with night. *Backward or counterclockwise rotation*s - go from night, to afternoon/evening, and end with morning.

Sleep Stages – the brain goes through 5 stages of sleep, beginning with light sleep (stages 1 & 2) and progressing to deep sleep (stages 3 & 4). The 5th stage, Rapid Eye Movement (REM) occurs after deep sleep and is associated with dreaming. The brain needs all 5 stages of sleep to achieve physical and mental restoration.

Split-shift – work schedules that are split into multiple periods rather than one continuous work period. These schedules can produce very long workdays especially if there is a morning work period followed by some hours off and ending with another work period.